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NATIONAL DAM INSPECTION PROGRAM. BROAD CREEK DAM (NDI-NUMBER-MD--ETC(U)
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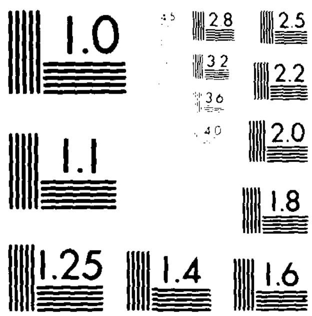

MICROCOPY RESOLUTION TEST CHART

LEVEL II

AD A088798

SUSQUEHANNA RIVER BASIN

BROAD CREEK, HARFORD COUNTY

MARYLAND

BROAD CREEK DAM

NDI NO. MD 00017

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY

Baltimore District, Corps of Engineers

Baltimore, Maryland 21203

Prepared By: Maryland Water Resources Administration

AUGUST 1979

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SUSQUEHANA RIVER BASIN

National Dam Inspection Program

BROAD CREEK DAM

~~HARFORD COUNTY, MARYLAND~~

NDI ~~NO.~~ MD -00017

Susquehanna River Basin, Broad Creek, Harford County, Maryland.

PHASE I INSPECTION REPORT.

~~NATIONAL DAM SAFETY PROGRAM~~

Prepared for: DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

Prepared by: WATER RESOURCES ADMINISTRATION
Department of Natural Resources
Tawes Building
Annapolis, Maryland 21401

Date: August 1979

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memo of understanding between State of md and Corps.

409111

<u>PREFACE</u>

This report is prepared under guidance contained in the "Recommended Guidelines for Safety Inspection of Dams," for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

NAME OF DAM:	Broad Creek Dam
STATE:	Maryland
COUNTY:	Harford
STREAM:	Broad Creek
DATE OF INSPECTION:	July 13, 1979

ASSESSMENT: Based on the evaluation of the conditions as they existed on the date of the inspection and as revealed by visual observations, the condition of Broad Creek Dam is assessed to be good. This dam is a small size Class I structure.

The spillway capacity (50 percent PMF) is classified as inadequate because it will not pass the recommended spillway design flood of full Probable Maximum Flood (PMF) according to the recommended criteria. However, overtopping of the dam by PMF is judged not to cause a breach of sufficient magnitude to increase the loss of life downstream. Consequently, additional hydraulic studies and remedial work to increase spillway capacity are not necessary.

The following remedial measures and recommendations should be implemented as soon as possible, except that item 1 should be repaired immediately:

Dam and Appurtenant Structures.

1. Repair the downstream abutment wing wall foundation at the right side of the spillway.

2. Correct surface drainage concentration and erosion at the toe of the downstream embankment slope at the right abutment.

3. Remove woody vegetation from the embankment slopes.

4. Repair the spalled concrete on the overflow spillway face.

5. Repair the leak in the sluice gate for the reservoir drain.

6. Remove timber debris from the spillway.

7. Post weight limit on the bridge over the spillway.

Operation and Maintenance Procedures.

1. Document operation and maintenance procedures in writing.

2. Develop a warning system to warn downstream residents of large spillway discharges during periods of heavy rainfall and runoff or failure of the dam.

SUBMITTED BY: WATER RESOURCES ADMINISTRATION
DAM SAFETY DIVISION

Date

APPROVED BY:

17 Sep 79

Date

James W. Peck

James W. Peck, Colonel
Corps of Engineers
District Engineer

BROAD CREEK DAM

MD 00017

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APPENDICES

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
BROAD CREEK DAM
NDI NO. MD 00017

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. The inspection was performed pursuant to the authority granted by the National Dam Inspection Act, Public Law 92-367, to the Secretary of the Army, through the Corps of Engineers, to conduct inspections of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Discription of Project.

a. Dam and Appurtenances. Broad Creek Dam consists of an ogee shaped concrete overflow spillway, 180 feet in length, with zoned earthen embankments 80 feet in length on the left side and 70 feet in length on the right side. The slope configuration is 2H to 1V, both upstream and downstream, and the maximum depth of fill is approximately 10 feet. Concrete retaining walls with wing walls on the upstream and downstream sides are located between each end of the spillway and the earthern embankments. The spillway crest is at elevation 178.0, the top of abutment walls at elevation 190.0 and the stream bed at elevation 153.6 yielding a dam height of 24.4 feet at the overflow section and 36.4 feet at the embankment. A drain opening 4 feet by 4 feet, extends through the left side of the overflow section with the control structure and gate located on the downstream face.

A bridge, 180 feet in length with 20 foot bays, spans the overflow spillway. The retaining walls at each end of the spillway form the bridge abutments, and the interior bays are supported by steel columns resting upon steel bearing plates on upper face of the ogee section. The primary structural elements of the bridge are steel with timber decking and guardrails.

b. Location. Broad Creek Dam is located on Broad Creek in Harford County, Maryland. The structure is approximately 2.5 miles from the confluence with the Susquehanna River which is 4 miles upstream from Conowingo Dam.

c. Size Classification. The maximum height of the dam is 36.4 feet. The reservoir volume to the top of the dam at elevation 190.0 is 958 acre-feet. Therefore, the dam is in the "small" size category.

d. Hazard Classification. Loss of life and property would likely result from a failure of the dam. Also loss of the State Road #623 bridge would likely result. Based on the above, the dam is classified in the high hazard category.

e. Ownership. The Broad Creek Dam is owned by the Baltimore Area Council of the Boy Scouts of America.

f. Purpose of Dam. The primary purpose of the dam is to provide a reservoir for recreation.

g. Design and Construction History. Broad Creek Dam was designed during 1947 and constructed during the winter of 1947 and 1948. Design and construction drawings were prepared by Whitman Requardt and Associates. The contractor for the dam is unknown and the only construction record consists of a design profile marked in red pencil to indicate concrete pour limits and the horizon of the rock foundation.

h. Normal Operating Procedures. Operating procedures are unwritten, but the reservoir is normally drained during the winter months.

1.3 Pertinent Data

a. Drainage Area The Broad Creek Dam has a drainage area of 30.99 square miles.

b. Discharge at Dam Site The maximum discharge at the dam site through the ungated spillway at elevation 178.0 is 28,957 cubic feet/sec. The maximum flood at the dam site is unknown.

c. Elevation (Report Datum at normal pool elevation 178 obtained from U.S.G.S. Quadrangle sheet; normal pool elevation according to design plan datum is 105.)

Top of Bridge Deck	191.5
Top of Spillway Abutment Walls & Embankment	190.0
Spillway Crest	178.0
Normal Tailwater	159.8
Drain Invert Elevation	159.0
Streambed at centerline of dam	153.6

d. Reservoir Lengths (miles)

Length of maximum pool	1.9
Length of normal pool	1.0

e. Storage (acre-feet)

Normal pool	254 @ elev. 178
Top of dam	958 @ elev. 190

f. Reservoir Surface (acres)

Normal pool	40.17

g. Dam

Type	Concrete gravity, earthen fill abutments
Length (feet)	330
Height (feet)	36.4
Base width (feet)	28.5
Side Slopes (over flow section)	Vertical upstream Ogee-shaped downstream
(abutments)	2H: 1V up and downstream

h. Diversion and Regulating Tunnel - None

i. Spillway

Type	Concrete ogee
Length of weir (feet)	180
Crest elevation	178
Gates	None

j. Regulating Outlets (Drain)- One 48" x 48" Chapman rectangular sluice gate mounted on downstream face of spillway.

SECTION 2
ENGINEERING DATA

2.1 Design:

a. Data Available. Broad Creek Dam was designed by Whitman, Requardt and Associates during 1947 and was constructed during the winter of 1947 - 1948. The only engineering data available for the design of the dam is contained on plans entitled "Boy Scout Dam on Broad Creek, July 1947". Limited subsurface explorations and brief soil descriptions are shown on the plans. These drawings, and drawings for a bridge over the spillway prepared by W.L. Newberry in 1965, are presented in Appendix C, "Location Map and Plans".

b. Design Features.

1. Embankment - The design drawings indicate the earthen embankment to be constructed in two zones with "selected fill" placed as an impervious core to a level three feet below the top of embankment. The impervious core was designed with a 1 horizontal to 1 vertical slope configuration and a top width of 3 feet. A concrete cutoff wall, approximately 4 feet in height, is located at midsection of the base of the impervious core and extends approximately 1 foot into undisturbed soil. The remainder of the embankment was constructed from common borrow apparently obtained in the pool area adjacent to the dam. The embankment was constructed at a 2 horizontal to 1 vertical upstream and downstream slope configuration with a 15 foot top width at elevation 190.

2. Overflow Spillway - The major portion of the dam consists of a concrete gravity ogee type overflow section 180 feet in length and approximately 25 feet in height at the maximum section with the crest at approximate elevation 178.0. The design drawings allow for both horizontal and vertical construction joints, but only the vertical joints contain key ways. The foundation level of the gravity section is indicated to be 1 to 2 feet below the weathered rock horizon.

At each end of the spillway, gravity retaining walls of plain concrete support the earthen embankment and form abutments for the bridge over the spillway. The walls were designed in three sections including an upstream wingwall, a middle bridge abutment section, and a downstream wingwall, all separated by expansion joints. The minimum thickness of wall is 2 feet at the top with uniformly increasing thickness with depth at a rate of 4H to 12V. Foundation material for the retaining structures is indicated to be rock.

3. Appurtenant Structures - A drain opening, 4 feet square, extends through the left side of the overflow section from the upstream face to a control structure located on the ogee section. The opening is horizontal at elevation 159 and is controlled on the downstream end by a 48 inch by 48 inch Chapman sluice gate.

The drain was initially designed to pass through the spillway at

an acute angle, but this configuration was altered during construction to a position perpendicular to the axis of the spillway. The bridge over the spillway is constructed of steel columns and underframing supporting a timber deck. The details of the bridge structure are shown on the drawings in Appendix C.

c. Design Data.

The only design data consists of the design drawings. Embankment design, stability analyses and structural computations for the dam, retaining walls, and bridge structure are not available.

2.2 Construction. The only construction data available is contained on a design plan and profile drawing, Sheet 3 of 7, marked in red pencil indicating the limits and dates of concrete pours and the foundation rock profile encountered.

2.3 Operation. Formal operating records have not been maintained. According to correspondence in the files of the Water Resources Administration, the reservoir is drained annually during the winter months.

2.4 Evaluation:

a. Availability. Design plans for the dam and bridge structure constitute the engineering data and are available in the files of the State of Maryland Department of Natural Resources, Water Resources Administration.

b. Adequacy.

1. Hydrology and Hydraulics - The original design considerations are unavailable. Refer to Section 5, Hydrology and Hydraulics and Appendix E.

2. Embankment - The embankment portions of the dam are limited in extent, low in height, and detailed engineering design analyses are unwarranted. Considering the details on the design drawings, the available engineering data is considered to have adequately addressed embankment design.

3. Overflow Spillway - Design data for the gravity spillway section is limited to dimensions and locations as shown on the design drawings. This data alone does not adequately assess the stability of the dam and limited stability calculations have been performed for the Phase I report. Refer to Section 6 and Appendix E.

4. Appurtenant Structures - Design data for the appurtenant structures is limited to that shown on the design drawings. Structural computations for the bridge over the spillway were not available for review.

c. <u>Operating Records</u>. Operating procedures are unwritten and could not therefore be assessed relative to stability of the dam.

d. <u>Post Construction Changes</u>. Subsequent to completion of the dam, a bridge was constructed over the spillway. No design computations for the bridge or the effect of the bridge loading on the spillway were available for review. Additional minor post construction changes consist of the installation of a half section of corrugated metal pipe around the drain inlet in an attempt to prevent sediment laden discharges downstream and the attachment of a small diameter water supply pipe to the backwall of the spillway.

e. <u>Seismic Stability</u>. The dam is located in seismic zone 1 and static stability with normal factors of safety should be sufficient to withstand minor earthquake induced dynamic forces.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The dam and its appurtenant structures were found to be in good overall condition at the time of the inspection, July 13, 1979. The complete visual inspection check list is presented in Appendix A.

b. Embankment.

1. The embankment is limited to abutment areas and appears uniform and stable with no indication of cracking, settlement of differential movement.

2. Loss of vegetative cover and minor erosion due to foot traffic was observed on the downstream face of each abutment embankment. At the downstream toe of the embankment at the right abutment, measureable erosion gullies have formed due to concentrated surface runoff from adjacent roadways.

3. Woody vegetation was observed on all the embankment slopes.

c. Overflow Spillway.

1. A concrete gravity overflow spillway forms the major portion of the dam and this structure was observed to be stable with no indications of major movement or distress.

2. The concrete surface of the ogee spillway was in good overall condition, but numerous spalls, 2 to 5 inches in depth, were detected on the lower portion of the spillway at construction joints.

3. The construction joints were generally rough and one horizontal joint on the left side of the spillway was open approximately one-quarter to one-half inch. Upon inserting a probe approximately 15 inches into the joint, silt issued forth.

4. A quantity of large timber debris has collected at each side of the spillway near the abutment walls.

5. The abutment walls contain minor hairline cracks but are well aligned with no indication of deleterious movement or distress. The concrete and expansion joint material are in good condition.

6. Broken rock foundation material for the downstream abutment wing wall on the right side of the spillway has been eroded such that only about 50 per cent of the bearing area remains beneath the last 15 feet of wall. The source of erosion appears to be the concentrated surface runoff from adjacent roadways and high discharges over the spillway.

d. Appurtentant Structures.

1. The drain opening sluice gate on the left side of the ogee spillway section leaks considerably due to improper seating of the gate. Although the gate operation was not demonstrated during the field inspection, the reservoir was drained within the past year and the gate is assumed to be functional. Access to the gate control is by boat and during periods of heavy spillway discharge, operation of the gate will not be possible.

2. The bridge structure over the spillway appears to be in good condition. Judging from the relatively light structural members, the bridge has a low capacity but no weight limits were posted.

e. Reservoir Area. The reservoir slopes are gently rolling and reasonably well vegetated. Some erosion was noted along the shore line and in beach areas. Although the area surrounding the reservoir appears stable, a history of sedimentation problems has been established over the last decade.

f. Downstream Channel. Discharge from the overflow spillway flows into a "stilling basin" formed in the natural stream channel by an accumulation of boulders 75 feet below the dam. The streambanks just below the dam are undercut and sloughing into the sides of the channel. The first mile of downstream reach consists of woodland, but the next 2 miles to the Susquehanna River are developed with more than 50 dwellings and summer cottages and the Maryland route 623 bridge over Broad Creek. In the event of a dam failure these dwellings would be affected and a hazard category of "high" appears appropriate.

3.2 Evaluation.

a. Embankment. The footpaths and minor erosion on the downstream faces of the abutment embankments could provide preferential flow paths and serious erosion in the event of overtopping. These areas should be stabilized with vegetation and foot traffic discouraged. The gully at the downstream toe of the right abutment embankment should be repaired and stabilized by controlling the surface runoff from the road areas. Woody vegetation on the embankment slopes should be removed.

b. Overflow Spillway. Although the spalls in the ogee spillway face do not presently affect the stability of the structure, they should be repaired to prevent accelerated deterioration of the concrete. The open construction joint on the left side of the spillway apparently extends through the dam to the silt laden pool water. The stability analyses in Section 6 and Appendix E, however, suggest that the effect of the open joint upon stability is negligible. The debris accumulated on the spillway should be removed to maintain maximum available flow capacity.

The abutment wing wall on the right downstream side of the spillway could become unstable at any time pending additional removal of foundation material. The foundation should be stabilized and the eroded bearing area restored. Surface runoff should be controlled and directed away from the structural elements of the dam.

c. Appurtenant Structures. The leak in the drain opening sluice gate should not affect the stability of the dam at this time. The gate, however, should be repaired to ensure continued good operation. According to the design plans in Appendix C, the bridge over the spillway was designed for a 5 ton truck and the structure should be appropriately posted to prevent loss of both the bridge and spillway capacity.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedure. The purpose of the dam is to provide recreation for the Broad Creek Memorial Boy Scout Camp. Discharges to the downstream areas are uncontrolled via the overflow spillway. Although the procedures are unwritten, the drain gate is operated annually to drain the reservoir during the winter months.

4.2 Maintenance of the Dam. The Baltimore Area Council of the Boy Scouts of America is responsible for the maintenance of the dam. No written maintenance program has been established and the general appearance of the dam and appurtenances indicates the present level of maintenance to be marginal.

4.3 Maintenance of Operating Facilities. The leaking drain gate suggests that maintenance of the operating facilities is marginal. Adoption of a written operating and maintenance policy should preclude similar conditions in the future.

4.4 Warning System. There is no formal warning system in effect.

4.5 Evaluation. The existing operation and maintenance procedures do not indicate conscientious effort to maintain the dam. Implementation of written operation and maintenance procedures, including a formal warning system for downstream residents, is recommended to ensure the good condition and safe operation of the dam.

SECTION 5

HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. Broad Creek Dam has a watershed area of 30.99 square miles and impounds a reservoir with a surface area of approximately 40.2 acres. The overflow spillway can safely discharge 28,957 cfs. No hydrologic or hydraulic design data were available for the preparation of this report.

b. Experience Data. No rainfall, runoff, or reservoir level data were available for review. The spillway has operated satisfactorily to date and the maximum pool elevation reported by operating personnel occurred during Hurricane Agnes in June, 1972. No stage or discharge data for this event are available at the dam.

c. Visual Observations. On the date of the inspection, timber debris clogged the left and right sides of the overflow spillway which could reduce the available flow capacity. Otherwise, the inspection revealed no conditions that would indicate the spillway could not operate satisfactorily in the event of a flood.

d. Overtopping Potential. As previously stated, Broad Creek Dam is classified as a small size dam in the high hazard category. Under the recommended criteria for evaluating spillway discharge capacity, such structures are required to pass one half to full Probable Maximum Flood (PMF). Since there exists a high concentration of dwellings downstream, full PMF is recommended as the spillway design flood. Various percentages of the PMF inflow hydrograph were routed through the reservoir to determine the percentage of PMF inflow that the dam can pass without overtopping. The analyses indicate that the 50% PMF level can be discharged without overtopping the embankment portions of the dam.

e. Spillway Adequacy. Since the spillway can just pass 50% PMF, an analysis was performed to determine the stability of the concrete spillway portion of the dam (refer to Section 6 and Appendix E). Under PMF loading, the spillway was found to be stable. Under PMF flow conditions, the embankment portions of the dam at the abutments would be susceptible to erosion and failure, but the breach width would be small compared to the full length of the dam. The breach analysis presented in Appendix E indicates that no significant increase of loss of life would occur in the event of the embankment failure. Consequently, the spillway is judged to be inadequate, but additional studies and remedial work to increase spillway capacity are judged to be unnecessary.

f. Downstream Conditions. As previously discussed in Section 3, damages to downstream dwellings and a State road are likely in the event of complete dam failure. Due to the concentration of dwellings along the stream banks loss of life is probable.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability:

a. Visual Observations.

1. Embankment - The embankment portions of the dam are relatively shallow and constructed at a 2H:1V configuration. Visual observations did not reveal any cracks or movement and the embankment slopes are judged to be stable under normal operating conditions. Woody vegetation was observed on all embankment slopes and minor erosion was detected on the left and right downstream slopes due to foot traffic. A gully, 1 to 2 feet in depth, has been formed along the downstream toe of the right embankment due to concentrated runoff from adjacent roadways. Although the woody vegetation and the minor slope erosion do not presently affect the stability of the dam, these items should be remedied before problems develop. As noted below in Section 6.1.a.3, the concentrated runoff has contributed to undermining of the right downstream wingwall.

2. Overflow Spillway Section - The concrete overflow spillway appeared stable with no indication of differential movement, distress, or major deterioration. The downstream spillway face contains numerous spalls, 1 to 2 inches in depth, distributed over the face at construction joints. At the left side of the spillway, a horizontal construction joint was open approximately 1/4 to 1/2 inch at the face. The open joint was probed to a depth of 15 inches and yielded a fine silt at that depth suggesting that the open joint extends to the upstream face of the spillway. Although the open joint might lead to increased sliding potential and increased uplift pressures, the stability analysis in Appendix E suggests that the effect will be insignificant.

Highly fractured rock foundation material of the downstream concrete wingwall at the right spillway/embankment abutment has been severely eroded such that approximately 50% of the bearing area has been removed beneath the downstream 15 feet of wall. The cause of the erosion appears to be a combination of high spillway discharges and concentrated surface runoff from roadways which is collected and flows along the downstream toe of the embankment at the right side of the dam. Although no cracking or movement was detected in the concrete, continued removal of foundation material could lead to failure of the wall and a small portion of the downstream embankment retained by the wall.

3. Appurtenant Structures - The only appurtenant structures associated with the dam are the drain opening through the left side of the spillway, the drain gate valve on the downstream face and the bridge over the spillway. The drain gate valve leaks considerably but this condition should not affect the stability of the dam. The bridge structure consists of steel columns, steel underframing and timber deck which appear to be in good condition.

b. Design and Construction Data: The only design data available for the dam consists of the design drawings. Limited construction data was obtained from a field marked copy of SHEET 3 of 7 of the design drawings showing the as-built configuration of the foundation rock line, the overflow spillway, drain opening, and concrete pours for the spillway. Design drawings with load assumptions are available for the bridge over the spillway but no design computations or construction records were found during the data review.

Considering the lack of original design computations, stability analyses were performed for the concrete overflow section at each joint at the maximum section. The loadings considered were PMF flow conditions, normal pool load plus ice, silt load, and uplift. The analyses and assumptions utilized to perform the analyses are presented in Appendix E and the results indicate the overflow section to be stable for both normal conditions and PMF loading. According to the geology report, Appendix F, the rock at the toe of the spillway is suspected to be erodible under high flow. However, considering the position of the resultant at foundation level during PMF, approximately 16 feet of material would have to be eroded before the dam became unstable. This amount of erosion is considered unlikely.

c. Operating Procedures. Detailed operating procedures are unwritten and were unavailable for review. According to correspondence in the Water Resources Administration files, the reservoir is emptied on an annual basis during the winter months. This operation should not affect the stability of the dam.

d. Post Construction Changes. Post construction changes consist of the construction of a roadway bridge over the spillway in 1965 and the installation of a half section of corrugated metal pipe around the drain intake to prevent sediment discharges downstream. Also, a small diameter water supply pipe was installed on the upstream face of the spillway just below the crest.

e. Seismic Stability. Broad Creek Dam is located in seismic zone 1 and seismic stability is predicated upon static stability with conventional margins of safety. The static stability is considered sufficient to withstand minor earthquake induced forces.

SECTION 7
ASSESSMENT, REMEDIAL MEASURES AND RECOMMENDATIONS

7.1 Dam Assessment:

a. Safety. Based upon visual inspection and review of design and construction documents, Broad Creek Dam appears to presently be in good overall condition. The foundation for the concrete abutment wing wall on the downstream right side of the spillway has been seriously undermined and should be repaired immediately to ensure stable conditions. Preliminary hydrologic and hydraulic analyses indicate the overflow spillway is capable of passing approximately 50 percent of PMF before the earthen embankments at the abutments are overtopped. Since stability analysis indicates the main spillway portion of the dam to be stable under PMF loading, only the earthen abutments are anticipated to fail during overtopping by PMF. A breach analysis assuming only abutment failure does not indicate an increase to loss of life downstream. Consequently, the spillway is judged to be inadequate, but additional hydraulic studies and remedial work to increase spillway capacity are not necessary.

b. Adequacy of Information. The available information consists of design drawings and one as-built drawing. This data is considered adequate to assess the project for the purposes of this Phase I report.

c. Urgency. With the exception of the abutment wing wall foundation repair which should be implemented immediately, the recommendations below should be implemented as soon as possible.

d. Necessity for Additional Studies. Due to the inadequacy of the spillway, detailed hydrologic and hydraulic analyses should be performed to formulate appropriate remedial modifications.

7.2 Remedial Measures and Recommendations:

a. Dam and Appurtenant Structures.

1. Repair the downstream abutment wing wall foundation at the right side of the spillway.

2. Correct surface drainage concentration and erosion at the toe of the downstream embankment slope at the right abutment.

3. Remove woody vegetation from the embankment slopes.

4. Repair the spalled concrete on the overflow spillway face.

5. Repair the leak in the sluice gate for the reservoir drain.

6. Remove timber debris from the spillway.

7. Post weight limit on the bridge over the spillway.

b. Operation and Maintenance Procedures.

1. Document operation and maintenance procedures in writing.

2. Develop a warning system to warn downstream residents of large spillway discharges during periods of heavy rainfall and runoff or failure of the dam.

APPENDIX A

CHECK LIST - VISUAL INSPECTION, SITE SKETCH, PHASE I

Check List
Visual Inspection
Phase I

Name of Dam Broad Creek Dam County Harford State Maryland ID# MD 00017

Type of Dam Concrete Gravity Hazard Category 1

Date(s) of Inspection 13 July 79 Weather Clear Temperature 90

Pool Elevation at Time of Inspection 105+ M.S.L.* Tailwater 86.8± M.S.L.*

*Plan Datum

Inspection Personnel:

Water Resources Administration	Maryland Geological Survey
Jeffrey O. Smith	Jonathan Edwards
Thomas J. Moynahan	
Alex Shields	
John Shober	

T.J. Moynahan, Recorder

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS AND REMARKS/RECOMMENDATIONS
SURFACE CRACKS	Dam abutments consist of relatively shallow earthfill, no surface cracks observed.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	At right abutment, road drainage outfall has contributed to undermining and erosion of foundation for downstream wingwall on right side of dam. Drainage channel, approx. 1.5 in depth, eroded to rock along Lt. & Rt. downstream abutment. Foot path on Rt. Abut. slightly eroded.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Embankment crest is traversed by tar & chipped road which is maintained regularly. No indication of movement or misalignment.
RIPRAP FAILURES	N/A

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATION AND REMARKS/RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	See Concrete/Masonry Dams section
ANY NOTICEABLE SEEPAGE	None
STAFF GAGE AND RECORDER	None
DRAINS	None

VISUAL INSPECTION
PHASE I
CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS AND REMARKS/RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	None detected
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Generally good condition-no indication of movement of concrete wing-walls. Construction joints tight-minor hairline cracks. Foundation for wingwall undermined-last 15 feet of downstream wingwall foundation (Rt. side) undermined; only 50% bearing area remains.
DRAINS	Drain through left side of dam controlled on downstream side by sluice gate.
WATER PASSAGES	N/A
FOUNDATION	Based upon outcrops on downstream side, left & right abutments, foundation consists of highly fractured serpentine. Fracture system exhibits relatively steep dip angles. No indication of seepage through foundation or abutment rock.

VISUAL INSPECTION
PHASE I
CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS AND REMARKS/RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	No cracking detected on spillway surfaces-joints rough-localized spalling 2-3" in depth on lower third of ogee section at piers 4&5 and around drain outlet structure.
STRUCTURAL CRACKING	Horizontal crack (1/16-1/8" open) noted on left side of dam between drain and lt. abutment. No displacement detected
VERTICAL AND HORIZONTAL ALIGNMENT	Good
MONOLITH JOINTS	None in dam, wingwalls poured in three panels (one as bridge abutment one upstream and one downstream). Joints filled with bituminous expansion joint material-good condition.
CONSTRUCTION JOINTS	Construction joints rough-minor spalling at edges. Uppermost joint open approx. 1/2 to 3/4"-joint was penetrated approx. 12" by probe at which point silt was encountered.
STAFF GAGE AND RECORDER	NONE

VISUAL INSPECTION
PHASE I
OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS AND REMARKS/RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A
INTAKE STRUCTURE	N/A
OUTLET STRUCTURE	N/A
OUTLET CHANNEL	Stilling basin consists of natural channel lined with riprap rubble.
EMERGENCY GATE	N/A

VISUAL INSPECTION
PHASE I
UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS AND REMARKS/RECOMMENDATIONS
CONCRETE WEIR	See Concrete/Masonry Dams
APPROACH CHANNEL	N/A
DISCHARGE CHANNEL	Natural stream channel
BRIDGE AND PIERS	Bridge and piers over spillway in good condition. Bridge appears not to have been constructed according to any accepted design standard.

VISUAL INSPECTION
PHASE I
GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS AND REMARKS/RECOMMENDATIONS
CONCRETE SILL	N/A
APPROACH CHANNEL	N/A
DISCHARGE CHANNEL	N/A
BRIDGE AND PIERS	N/A
GATES AND OPERATION EQUIPMENT	N/A

VISUAL INSPECTION
PHASE I
INSTRUMENTATION

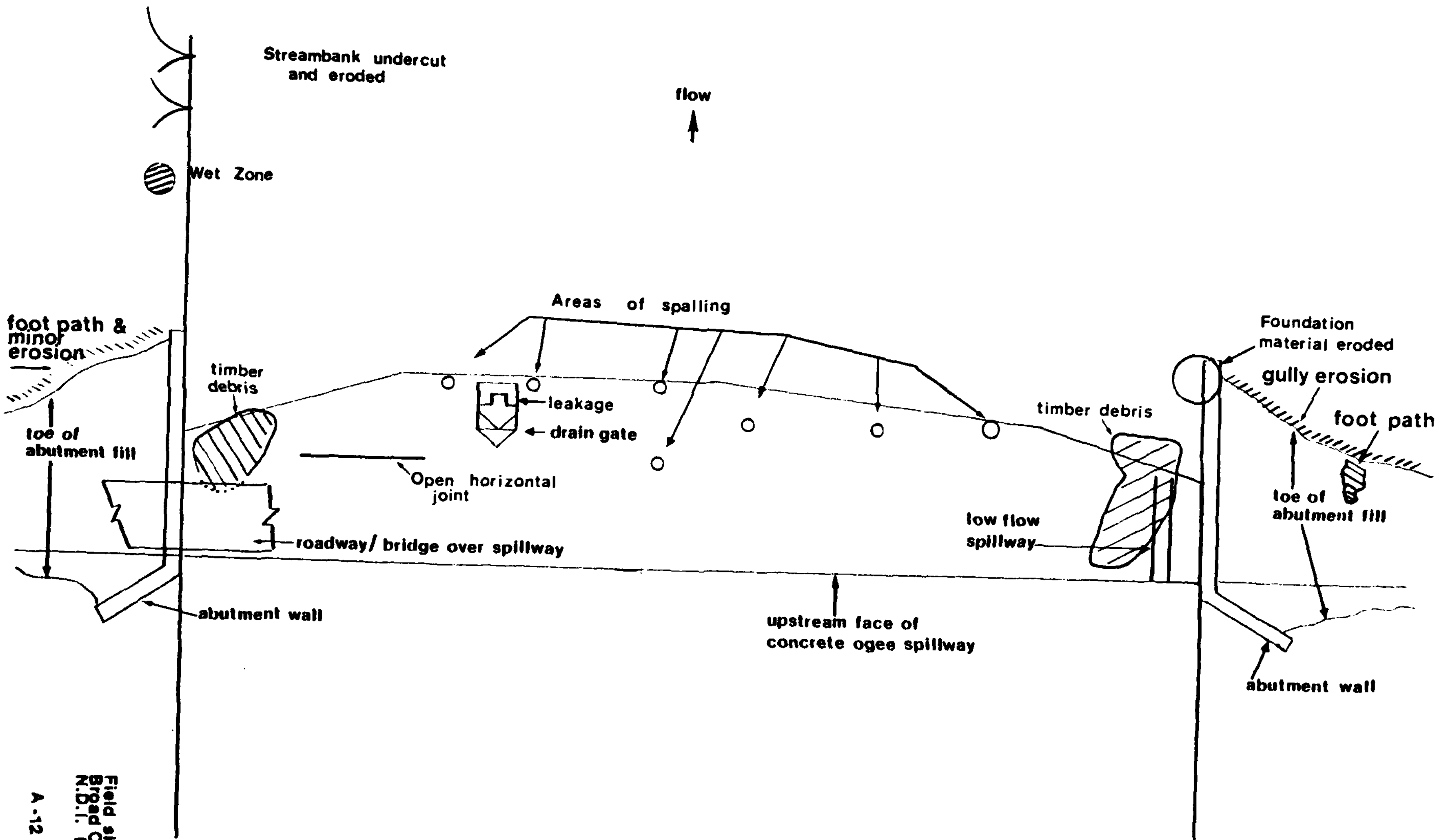
VISUAL EXAMINATION OF	OBSERVATIONS AND REMARKS/RECOMMENDATIONS
MONUMENTATION/SURVEYS	U.S.G.S. horizontal control 400' beyond left abutment.
OBSERVATION WELLS	N/A
WEIRS	N/A
PIEZOMETERS	N/A
OTHER	N/A

VISUAL INSPECTION
PHASE I
RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS AND REMARKS/RECOMMENDATIONS
SLOPES	Heavily wooded and stable-minor erosion in vicinity of beach areas.
SEDIMENTATION	Reservoir exhibits severe sediment accumulation-sediment level measured to be 4.2 feet below spillway crest.

VISUAL INSPECTION
PHASE I
DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS AND REMARKS/RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Boulder accumulation approx. 100' downstream from dam. Channel bottom appears to be rock lined and stable.
SLOPES	Earthen slopes just downstream from dam steep and severely eroded.
APPROXIMATE NOL OF HOMES AND POPULATION	Approx. 15 homes and summer cottages located 1 mile downstream from dam. Md RTE 623 bridge 2 miles downstream.



Field sketch
Broad Creek Dam
N.D.I. MD 17

APPENDIX B

CHECK LIST - HYDROLOGIC AND HYDRAULIC ENGINEERING DATA

PHASE I

DAM NAME: BROAD CREEK
ID# MD: 00017

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Cropland, chester silt loam

ELEVATION TOP OF NORMAL POOL(STORAGE CAPACITY): 178.0 (327 Ac-Ft)

ELEVATION TOP OF FLOOD CONTROL POOL (STORAGE CAPACITY): unknown

ELEVATION MAXIMUM DESIGN POOL: unknown

ELEVATION TOP OF DAM: 190.0 (1030 Ac-Ft)

CRESTS

a. Elevation 178.0
b. Type concrete ogee
c. Length 180 feet
d. Location Spillover entire gravity section available for overflow
e. Number and Type of Gates none

OUTLET WORKS (DRAIN):

a. Type 4'x4' Chapman rectangular sluice gate
b. Location left center of gravity section gated on downstream face of ogee
c. Entrance Inverts 159.0
d. Exit Inverts 159.0

HYDROMETEOROLOGICAL GAGES:

a. Type daily totals
b. Location Conowingo Dam
c. Records 44 yrs. of record

ITEM	REMARKS
SPILLWAY PLAN	see plan sheet 2 and 3
SECTIONS	see plan sheet 4 and 7
DETAILS	see plan sheet 4 and 7
OPERATION EQUIPMENT PLANS & DETAILS	See sheet for Sluice Gate and Trash Rack Details dated 12/17/47, revised 1/20/48.
MONITORING SYSTEMS	none

ITEM	REMARKS
MODIFICATION	Bridge over spillway installed in 1965 design plans (2 sheets) and materials sheet (1 sheet) dated 10/22/65 available, half-section of C.M.P. placed over inlet end of 4ft x 4ft drain in 1976 to prevent sediment discharges downstream.
HIGH POOL RECORDS	not recorded
POST CONSTRUCTION ENGINEERING STUDIES & REPORTS	See MISC. below
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	none located
MAINTENANCE OPERATION RECORDS	No written history available

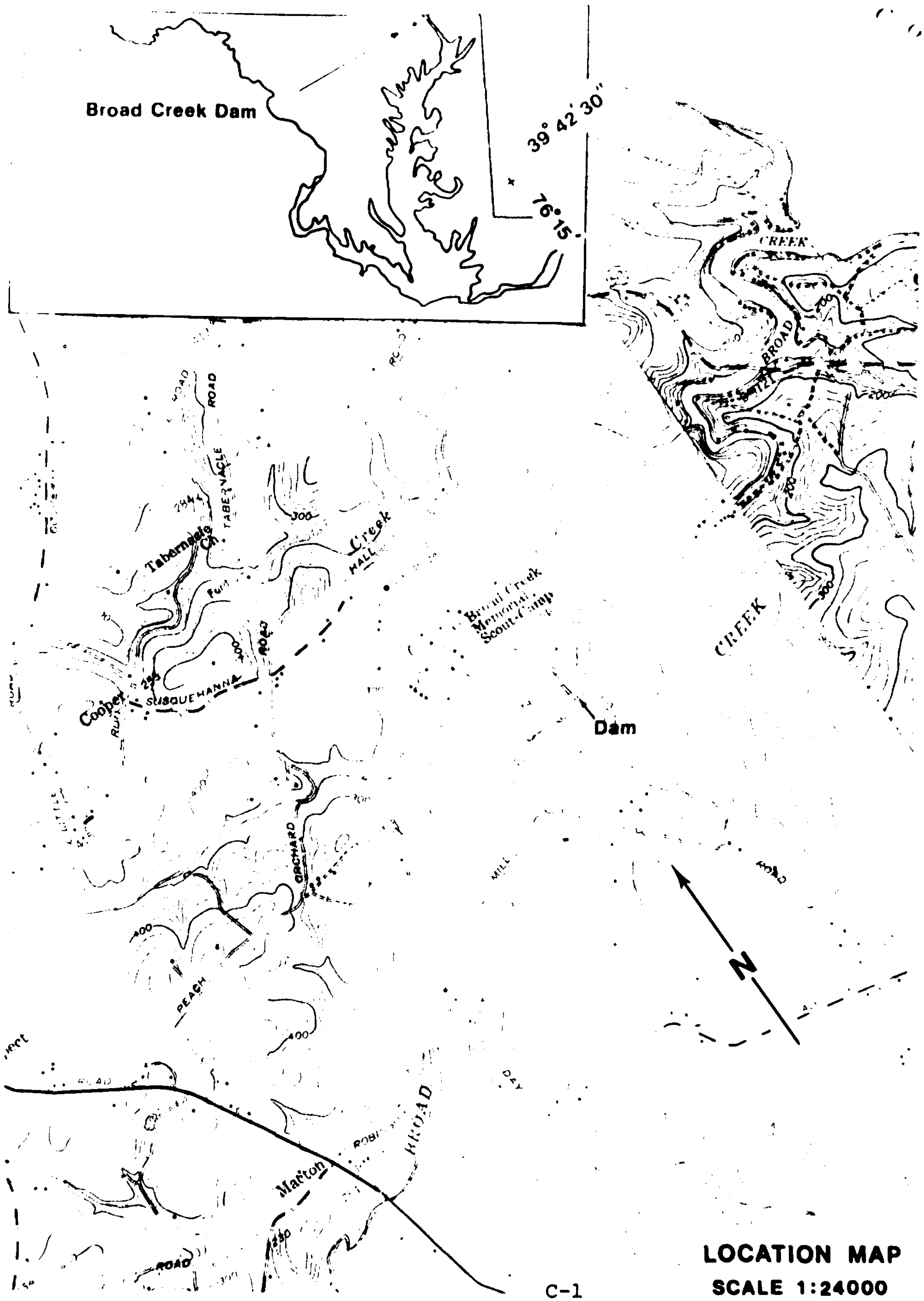
ITEM	REMARKS
MISC.	A report on dam by Acres American Incorporated, Columbia, Md. prepared for the Johns Hopkins University Applied Physics Lab in their study for the U.S. Dept. of Energy entitled "Problems of Hydroelectric Development at Existing Dams", April, 1979.
DESIGN REPORTS	none located
GEOLOGY	none located
DESIGN COMPUTATIONS HYDROGOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	none located
MATERIALS INVESTIGATIONS, BORING RECORDS LABORATORY, FIELD	none located

ITEM	REMARKS
POST CONSTRUCTION SURVEY OF DAM	none
AS BUILT DRAWINGS	Seven design drawings of dam, 3 drawings of bridge, one drawing of revised drain and one red-line revision of plan sheet 3 showing encountered rock lines and as-built construction joints are available in the files at the Broad Creek Boy Scout Reservation.
REGIONAL VICINITY MAP	available
CONSTRUCTION HISTORY	No narrative located, red-line revision of plan sheet 3 is available.
TYPICAL SECTIONS OF DAM	See sheets 4 and 7

ITEM	REMARKS
OUTLETS-PLANS -DETAILS -CONSTRAINTS -DISCHARGE RATINGS	see plan sheet dated 12/17/47, revised 1/20/48 see plan sheet dated 12/17/47, revised 1/20/48 see Appendix E-Analyses
RAINFALL/RESERVOIR RECORDS	Pool records are unrecorded

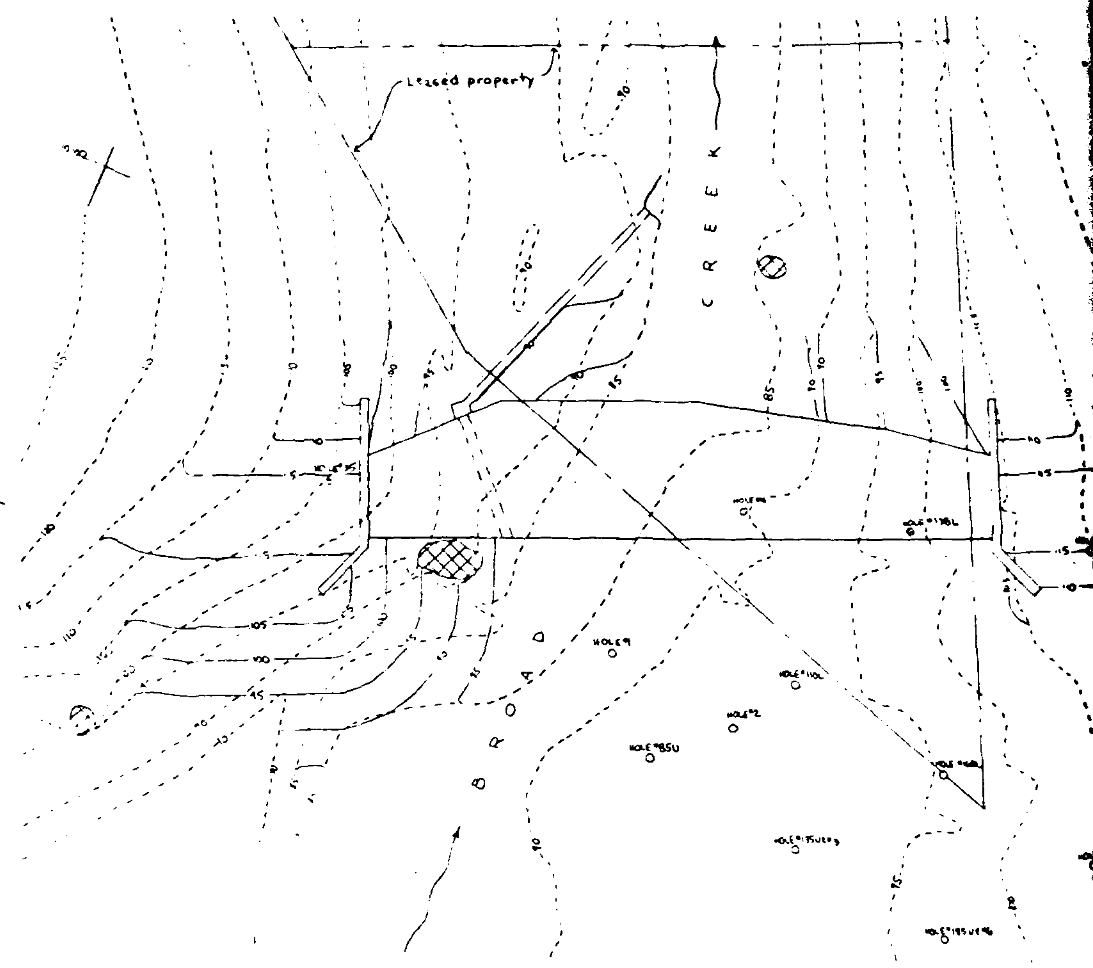
APPENDIX C

LOCATION MAP & PLANS



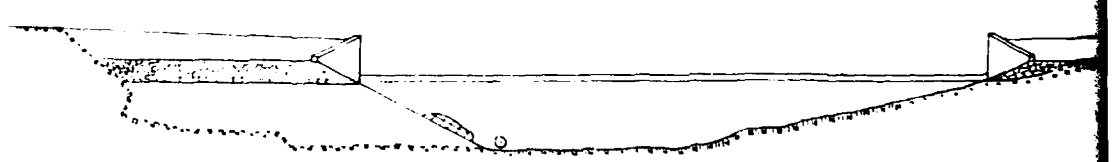
LOCATION MAP

SCALE 1:24000



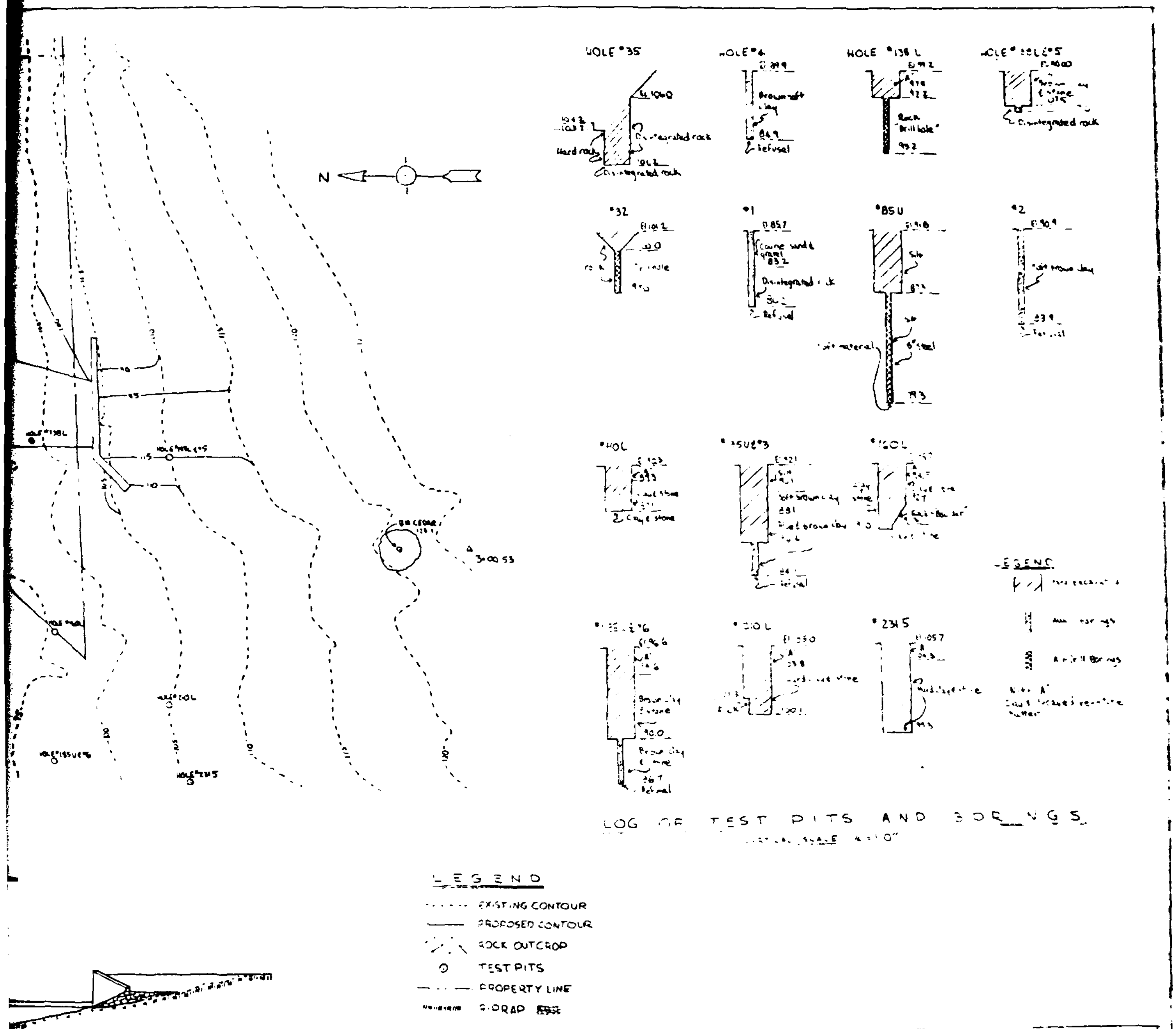
GRADING PLAN

SCALE 1"= 20'



UPSTREAM ELEVATION

SCALE 1"= 20'



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BOY SCOUTS OF AMERICA
BALTIMORE AREA COUNCIL

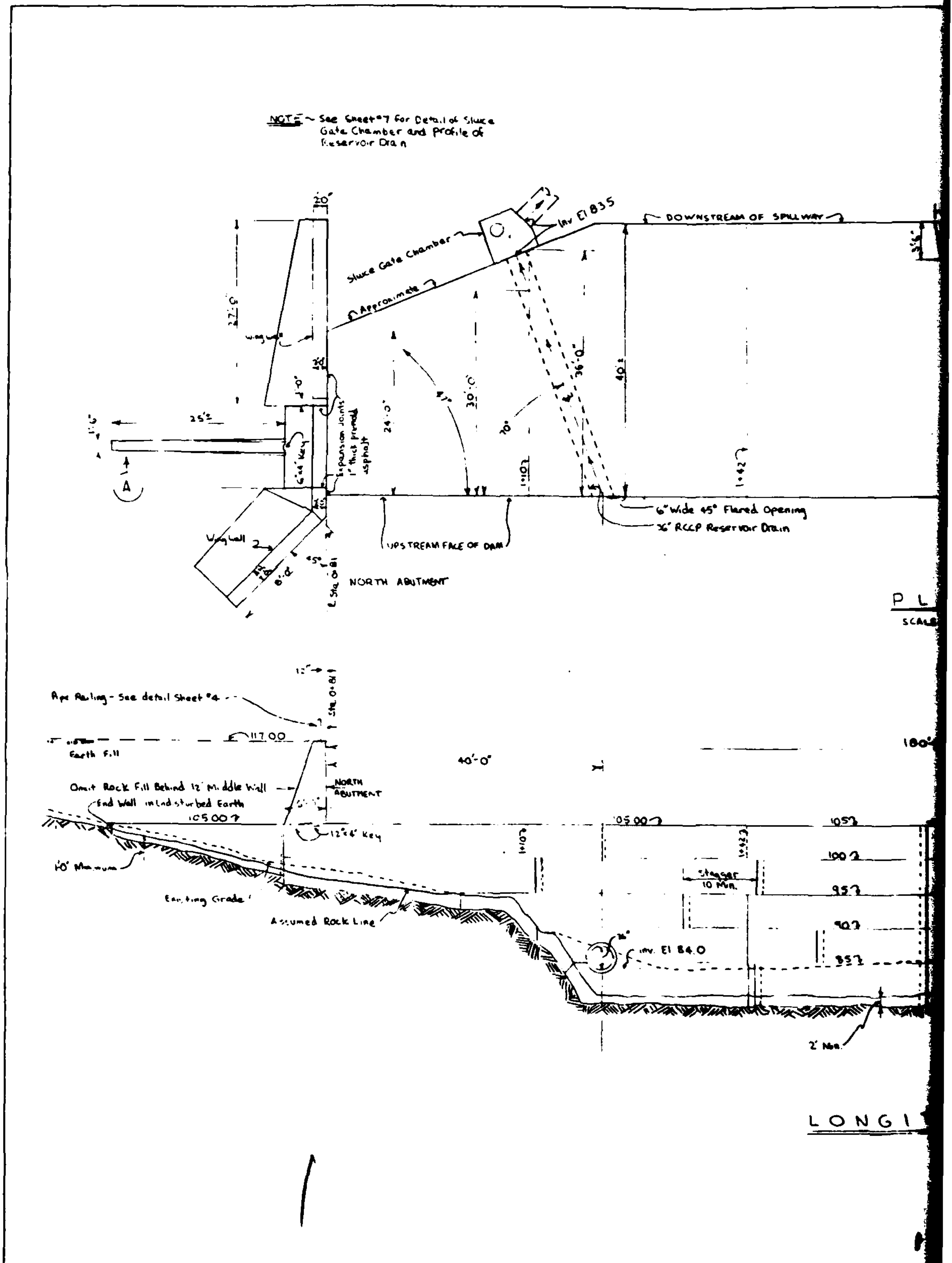
BOY SCOUT DAM ON BROAD CREEK

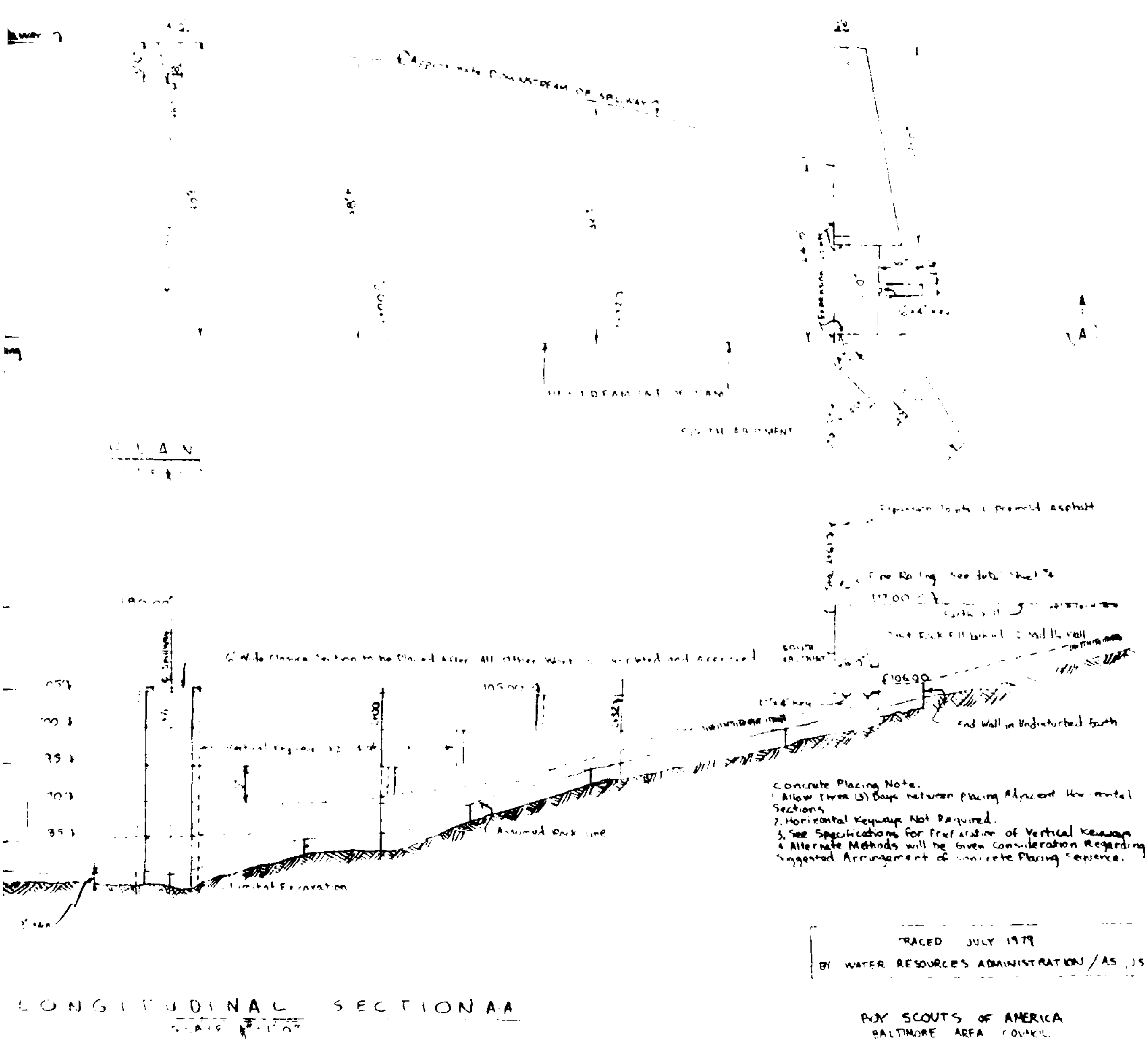
SITE AND GRADING PLAN

WHITMAN, REQUARDT AND ASSOCIATES — CONSULTING ENGINEERS

JULY 1947 — SHEET 2 OF 7

2


NOTE ~ See Sheet #7 for Detail of Sluice Gate Chamber and Profile of Reservoir Drain
Sluice Gate Chamber
Approximate
Inv. El 83.5
DOWNSTREAM OF SPILLWAY
Wingwall
Expansion Joints 1" thick premold asphalt
6"x6" Key
UPSTREAM FACE OF DAM
6" Wide 45° Flared Opening
36" RCCP Reservoir Drain
NORTH ABUTMENT
Pipe Railing - See detail Sheet #4
117.00
Earth Fill
Omit Rock Fill Behind 12' Middle Wall
End Wall in Undisturbed Earth
105.00
12"x6" Key
10' Minimum
Existing Grade
Assumed Rock Line
Inv. El 84.0
Stagger 10 Min.
2' Min.
40'-0"
P L
SCALE
L O N G I



Concrete Placing Note.
1. Allow three (3) Days between Placing Adjacent Horizontal Sections.
2. Horizontal Keyways Not Required.
3. See Specifications for Preparation of Vertical Keyways.
4. Alternate Methods will be Given Consideration Regarding Suggested Arrangement of Concrete Placing Sequence.

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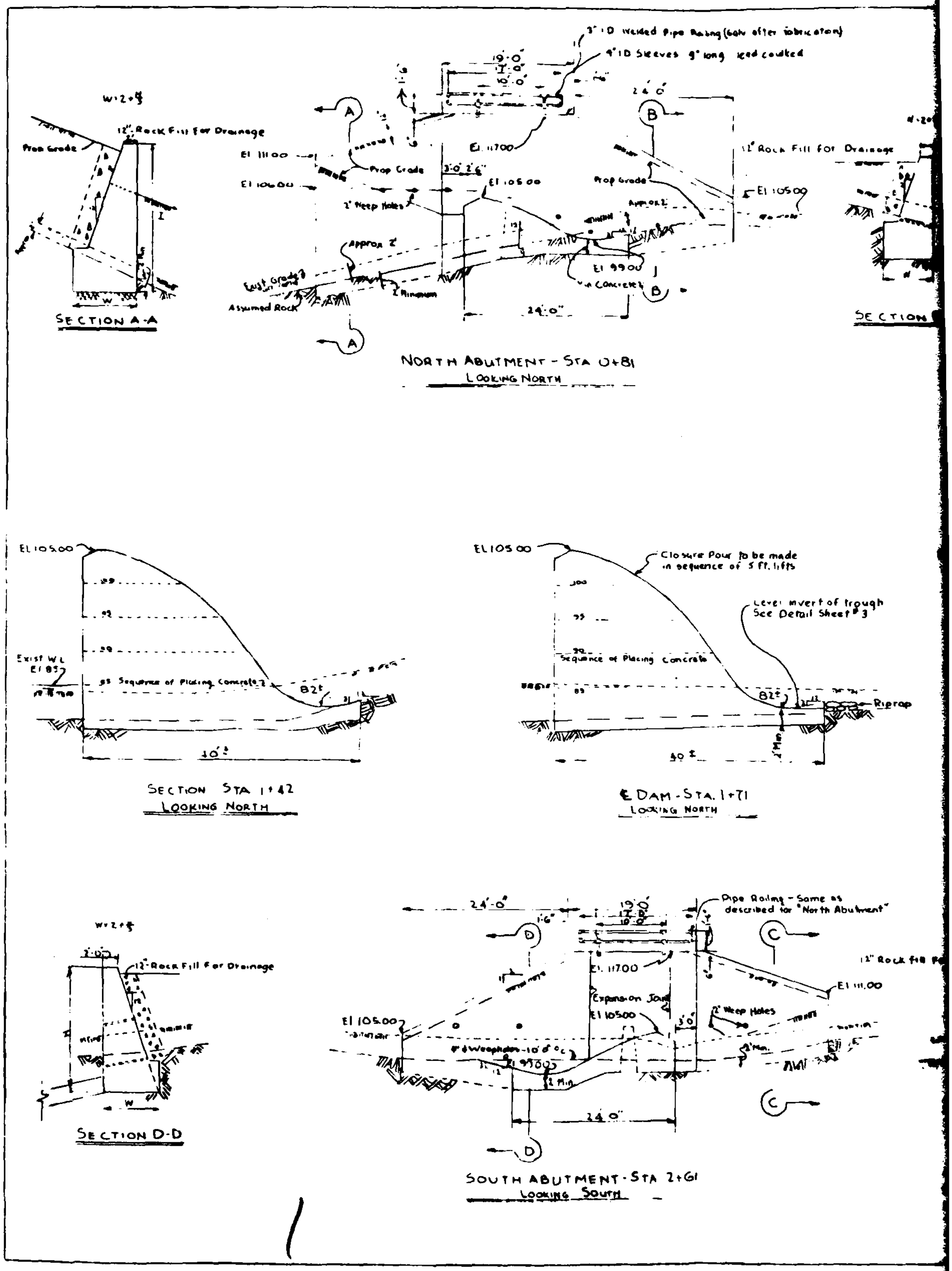
BALTIMORE AREA COUNCIL

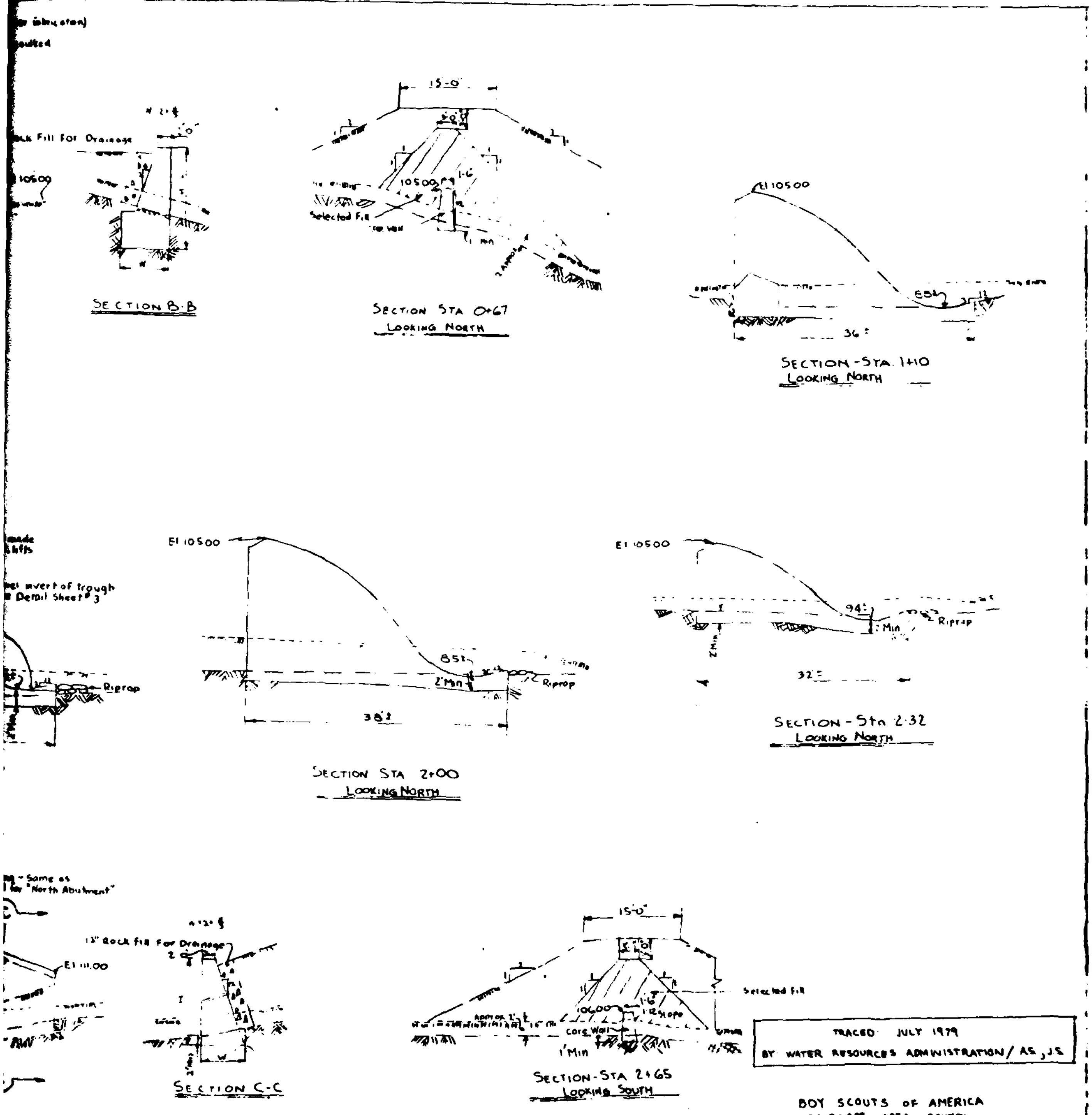
BOY SCOUT DAM ON BROAD CREEK

PLAN AND LONGITUDINAL SECTIONS

WHITMAN, REQUARDT AND ASSOCIATES CONSULTING ENGINEERS
JULY 1947 SHEET 3 OF 7



W=2+4/3
12" Rock Fill For Drainage
Prop Grade
SECTION A-A
3" I.D. Welded Pipe Railing (Galv after fabrication)
4" I.D. Sleeves 9" long lead caulked
19'-0"
17'-0"
10'-0"
24'-0"
El 111.00
El 106.00
El 117.00
El 105.00
Prop Grade
2" Weep Holes
Approx 2'
Exist Grade
Assumed Rock
2' Minimum
El 99.00
Concrete
NORTH ABUTMENT - STA 0+81
LOOKING NORTH
SECTION
EL 105.00
Exist W.L.
El 85
Sequence of Placing Concrete
30'±
SECTION STA 1+42
LOOKING NORTH
EL 105.00
Closure Pour to be made in sequence of 5 ft. lifts
Level invert of trough
See Detail Sheet #3
Sequence of Placing Concrete
Riprap
2' Min
30'±
℄ DAM - STA. 1+71
LOOKING NORTH
W=2+4/3
3'-0"
12" Rock Fill For Drainage
SECTION D-D
24'-0"
19'-0"
17'-0"
10'-0"
Pipe Railing - Same as described for "North Abutment"
12" Rock Fill For Drainage
El 117.00
Expansion Joint
El 105.00
El 105.00
El 111.00
2" Weep Holes
El 99.00
2' Min.
24'-0"
SOUTH ABUTMENT - STA 2+61
LOOKING SOUTH



Traced July 1979
By Water Resources Administration / AS, JS

BOY SCOUTS OF AMERICA
BALTIMORE AREA COUNCIL

BOY SCOUT DAM ON BROAD CREEK

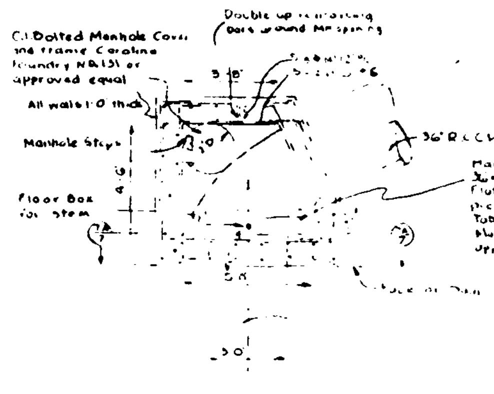
DETAILS OF TYPICAL SECTIONS

WHITMAN REQUARDT AND ASSOCIATES — CONSULTING ENGINEERS
JULY 1947 — SHEET 4 OF 7

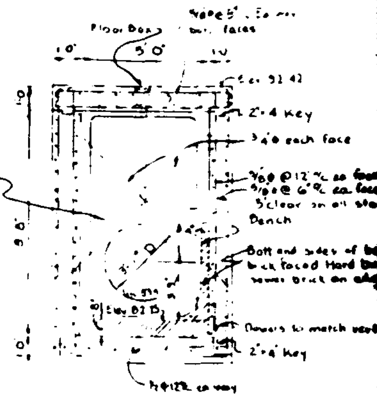
LEGEND
Existing Grade
Assumed Rock
Proposed Grade

Note:
For detail of Ogee see Sheet #1

Scale 1/8" = 1'-0"

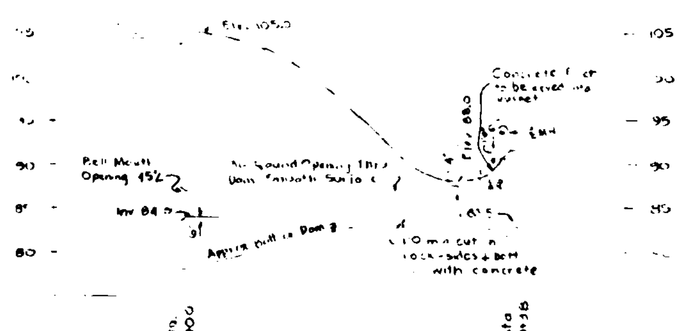


PLAN SECTION BELOW TOP SLAB
Scale 3/8"=1'-0"

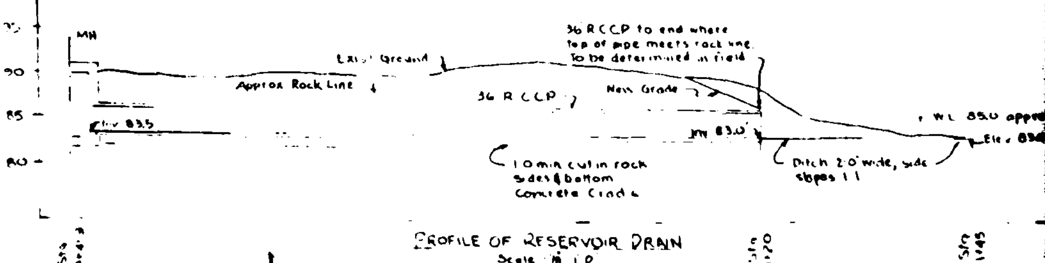


SECTION 2A
Scale 3/8"=1'-0"

SLUICE GATE CHAMBER



PROFILE OF RESERVOIR DRAIN
Scale 1/8"=1'-0"



PROFILE OF RESERVOIR DRAIN
Scale 1/8"=1'-0"

o min

Key

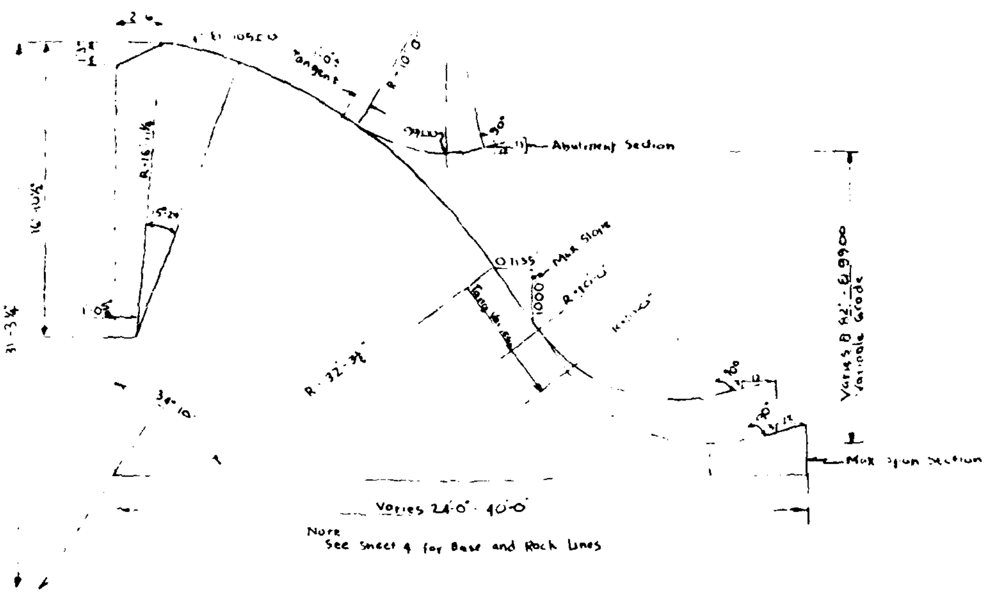
each face

@ 12" c. ea face
@ 6" c. ea face
Sclear 3in all Steel
bench

and sides of bench
faced Hard burned
brick on edge

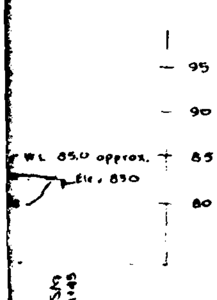
to match vertical steel

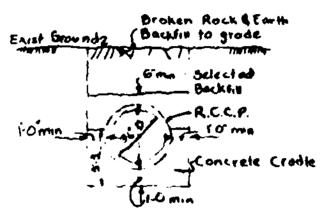
Key



Note
See Sheet 4 for Base and Rock Lines

SHAPE OF OGEE OF DAM
Scale ¼" = 1'-0"





TYPICAL TRENCH SECTION
Scale ½"=1'-0"

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BY: WATER RESOURCES ADMINISTRATION / AS, JS

BOY SCOUTS OF AMERICA
BALTIMORE AREA COUNCIL

BOY SCOUT DAM ON BROAD CREEK

MISCELLANEOUS DETAILS

WHITMAN, REQUARDT AND ASSOCIATES CONSULTING ENGINEERS
JULY 1957 SHEET 7 OF 7

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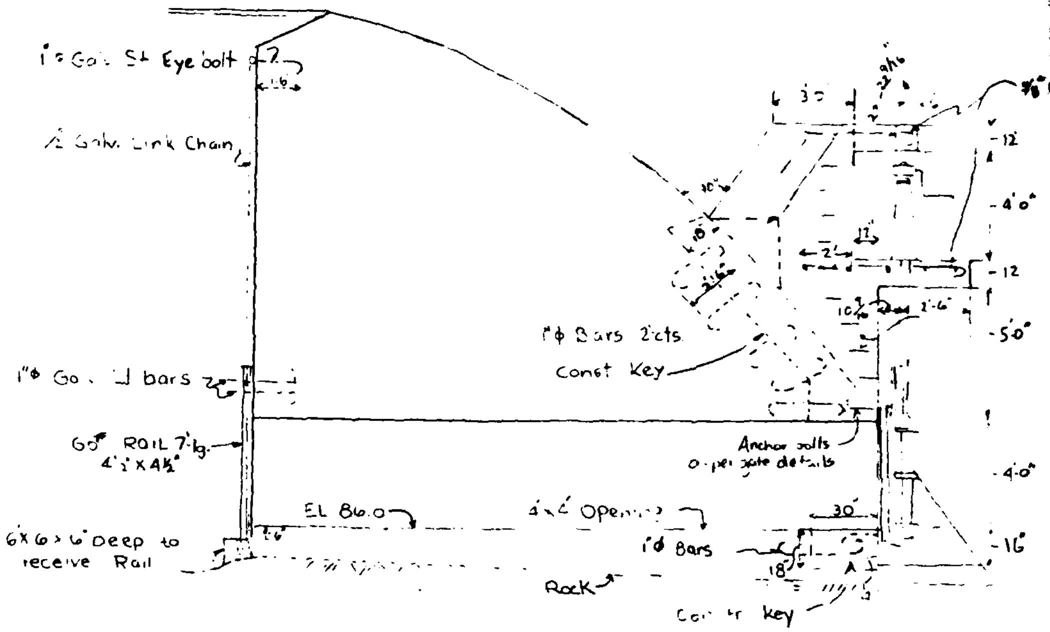
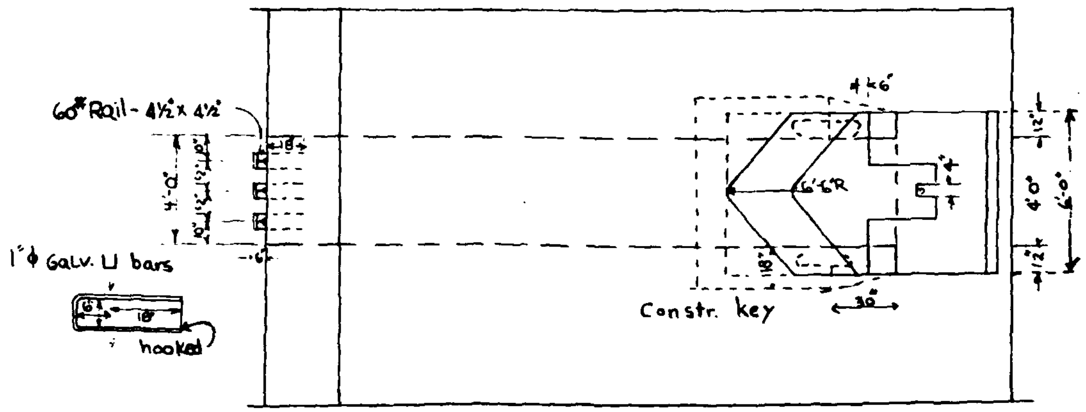
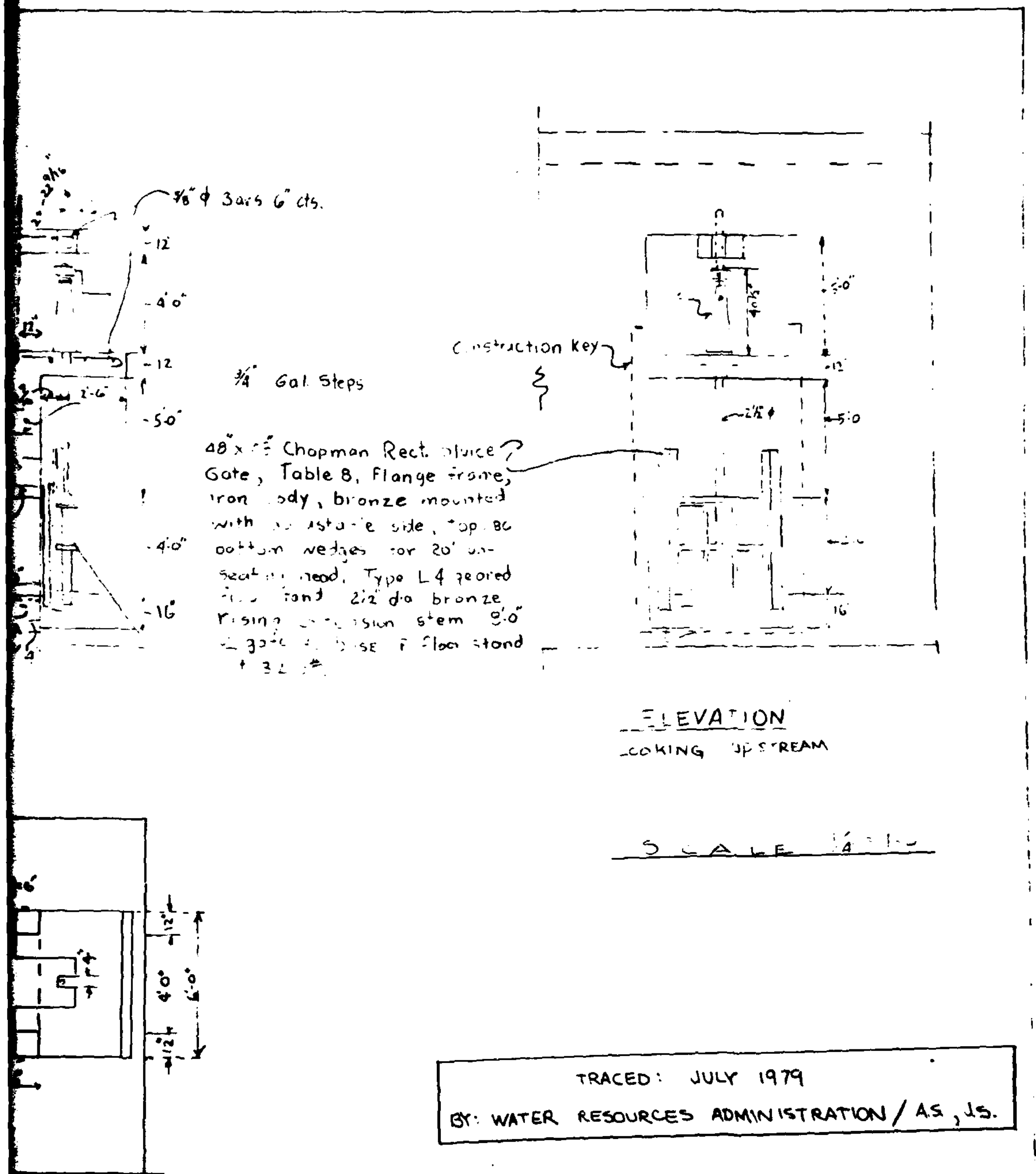


SECTION

Scale ½" = 1'-0"



PLAN



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BY: WATER RESOURCES ADMINISTRATION / A.S., J.S.

BOY SCOUTS OF AMERICA
BALTIMORE AREA COUNCIL

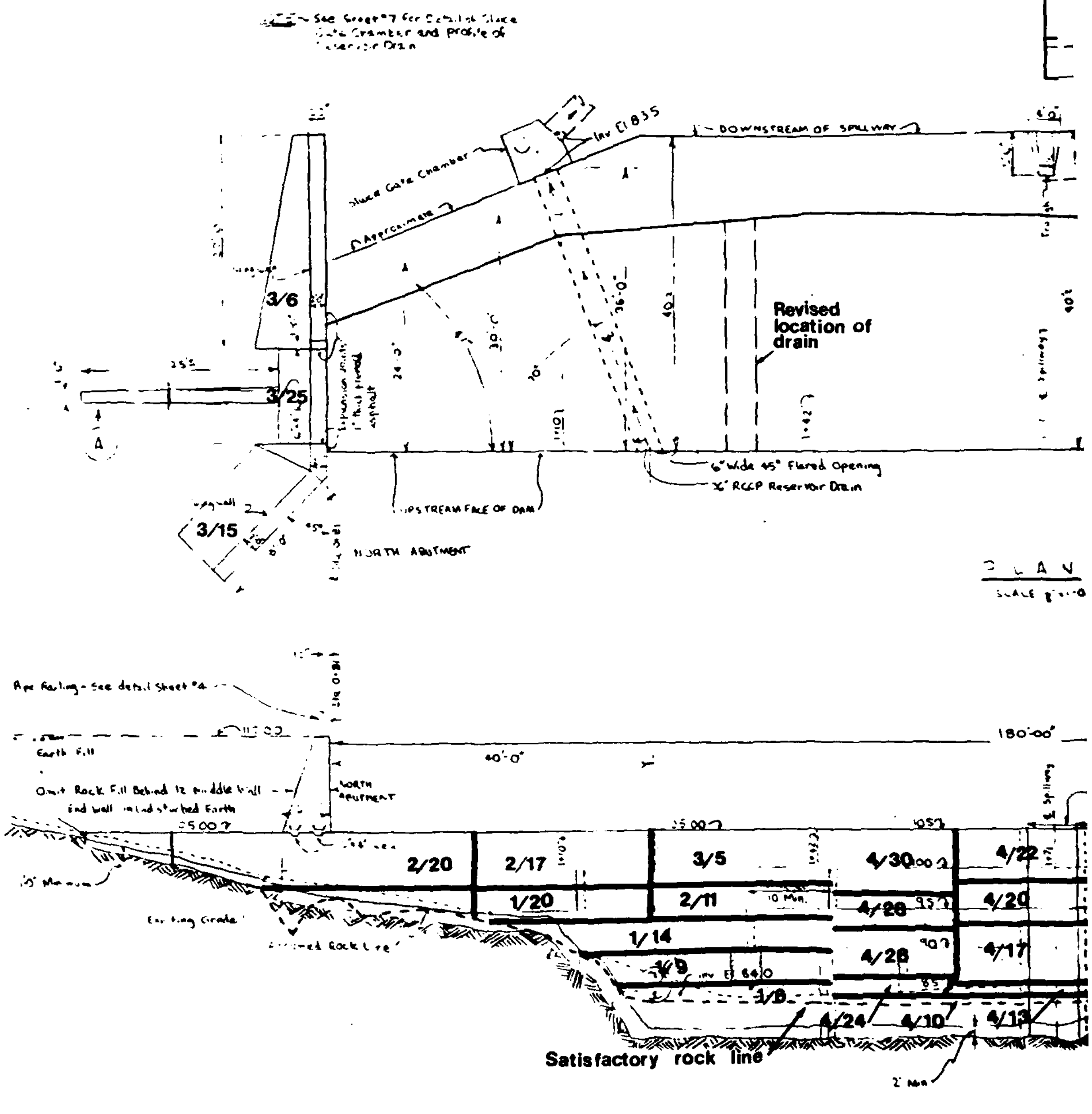
BOY SCOUTS DAM BROAD CR

PRELIMINARY SLUICE GATE & TRASH RACK DETAILS

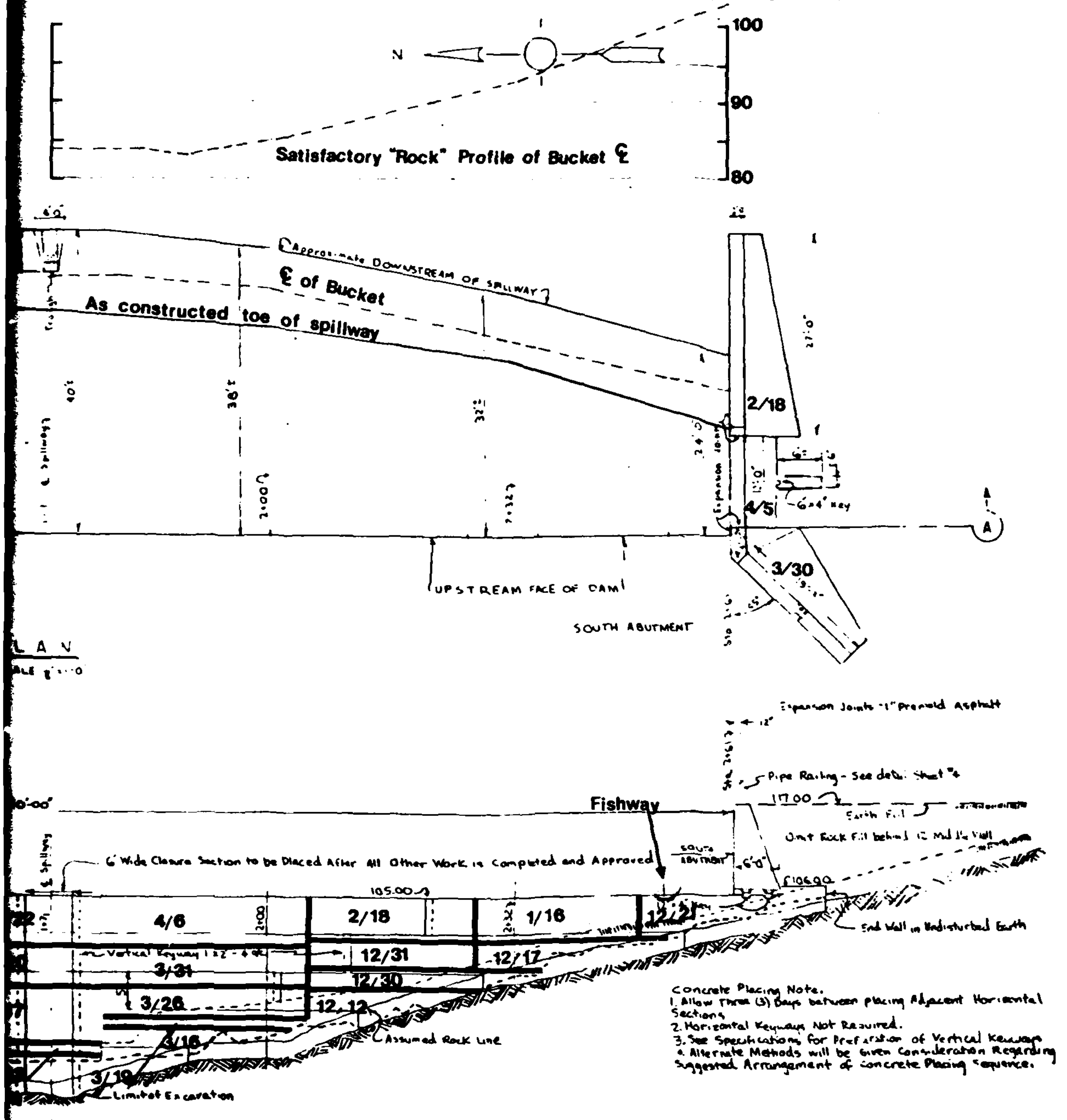
WHITMAN, REQUARDT & ASSOCIATES Consulting Engineers

Dec. 17 1947 Rev. -20-43

C-6



Note:
Encountered rock lines, & "as-built" details copied from "red-line" revision of plan sheet 3 filed with owner
1/8 represents the concrete pour dates during the period Dec.12,1947–April 15,1948



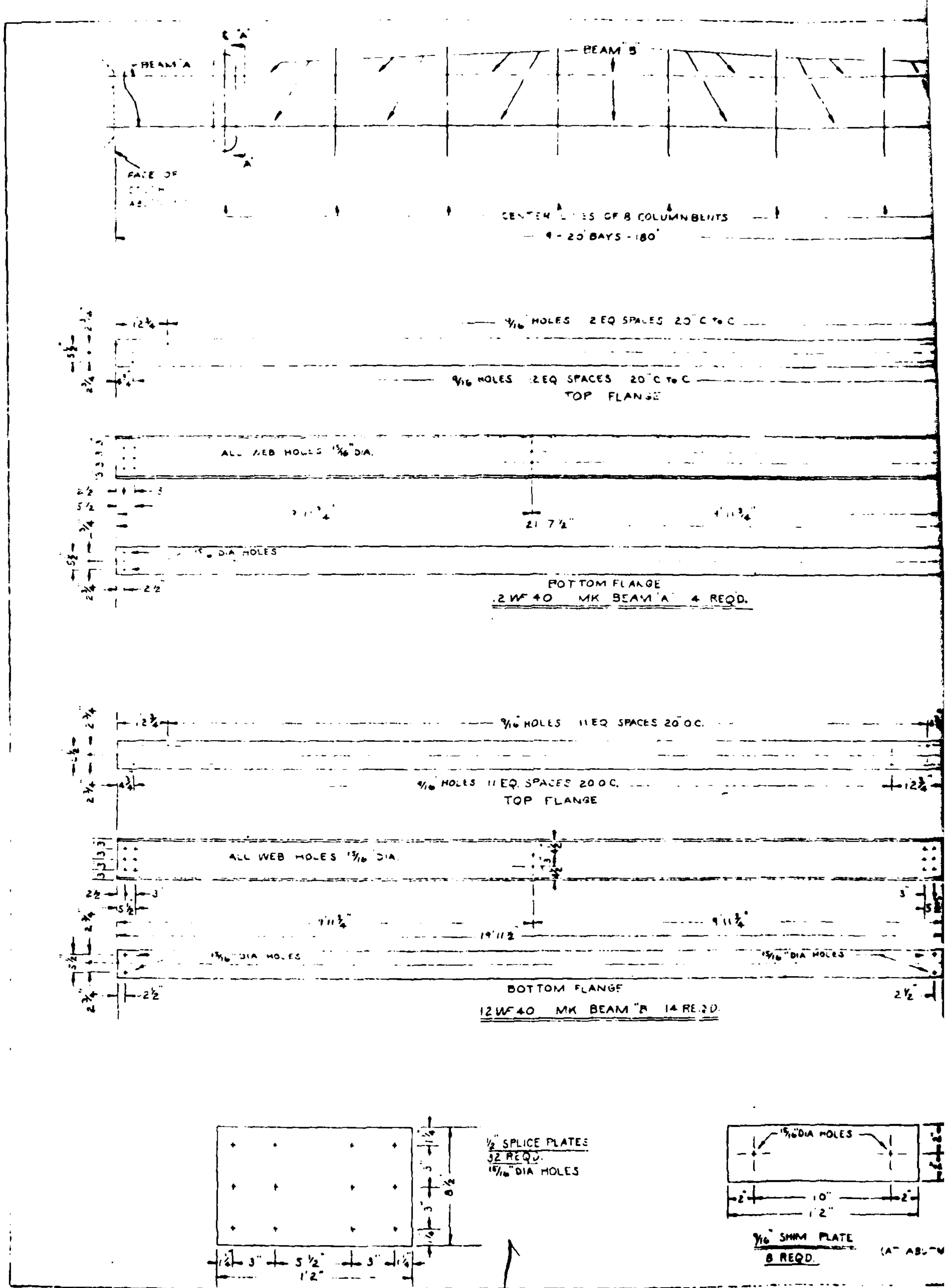
...TUDINAL SECTION A-A
SCALE 1/8"=1'-0"

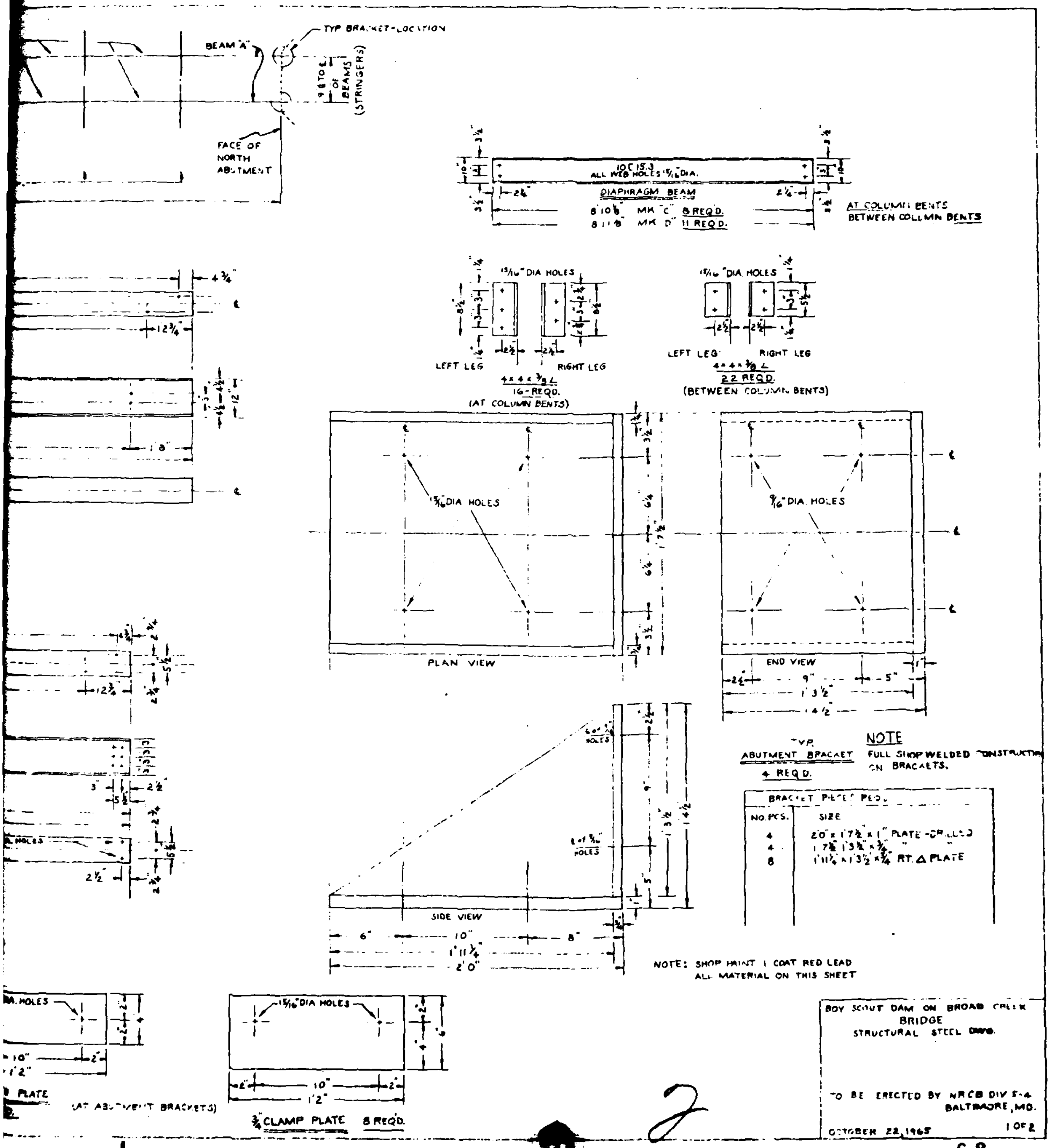
TRACED JULY 1979
BY WATER RESOURCES ADMINISTRATION / AS, JS.

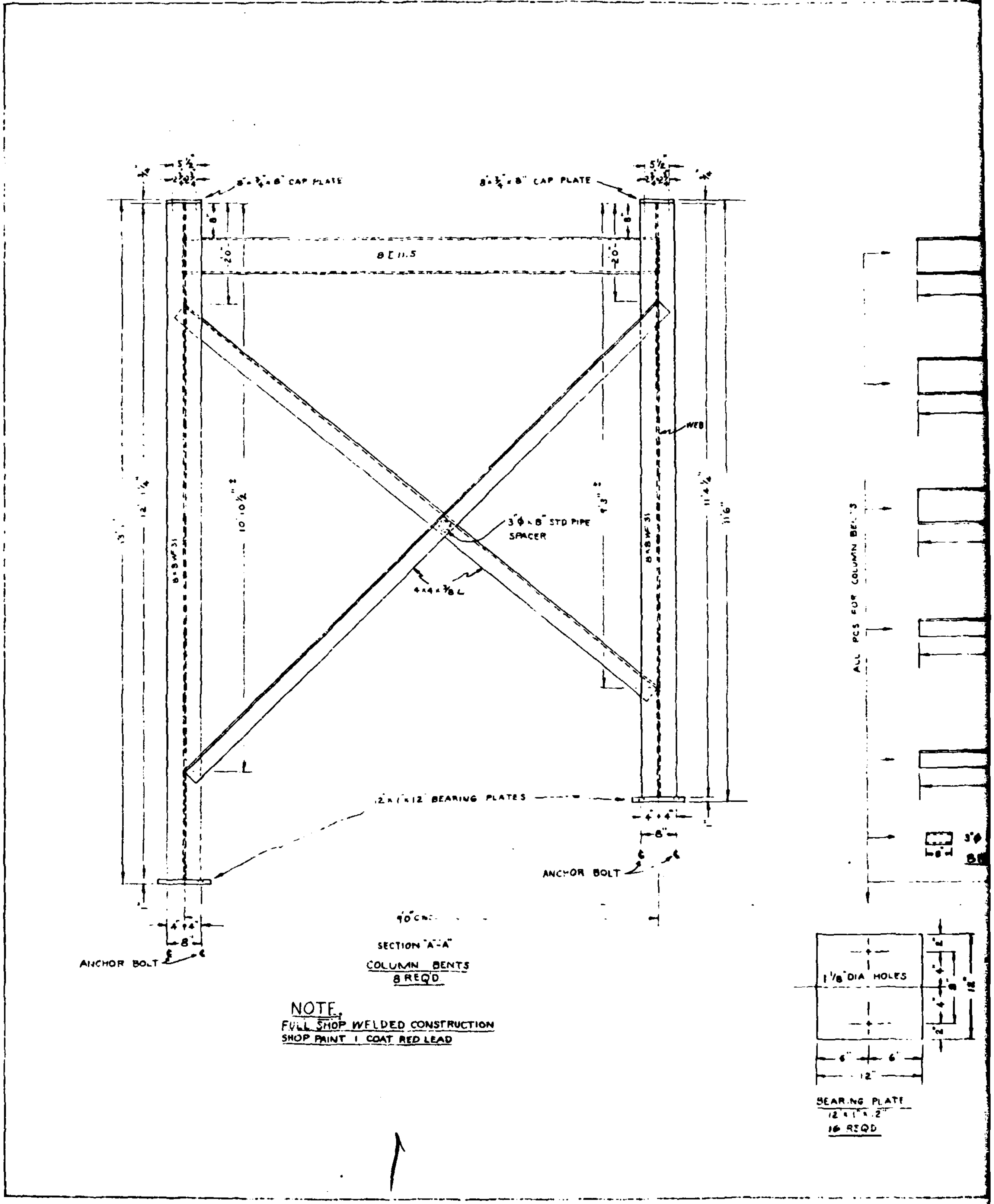
BOY SCOUTS OF AMERICA
BALTIMORE AREA COUNCIL

BOY SCOUT DAM ON BROAD CREEK
PLAN AND LONGITUDINAL SECTIONS

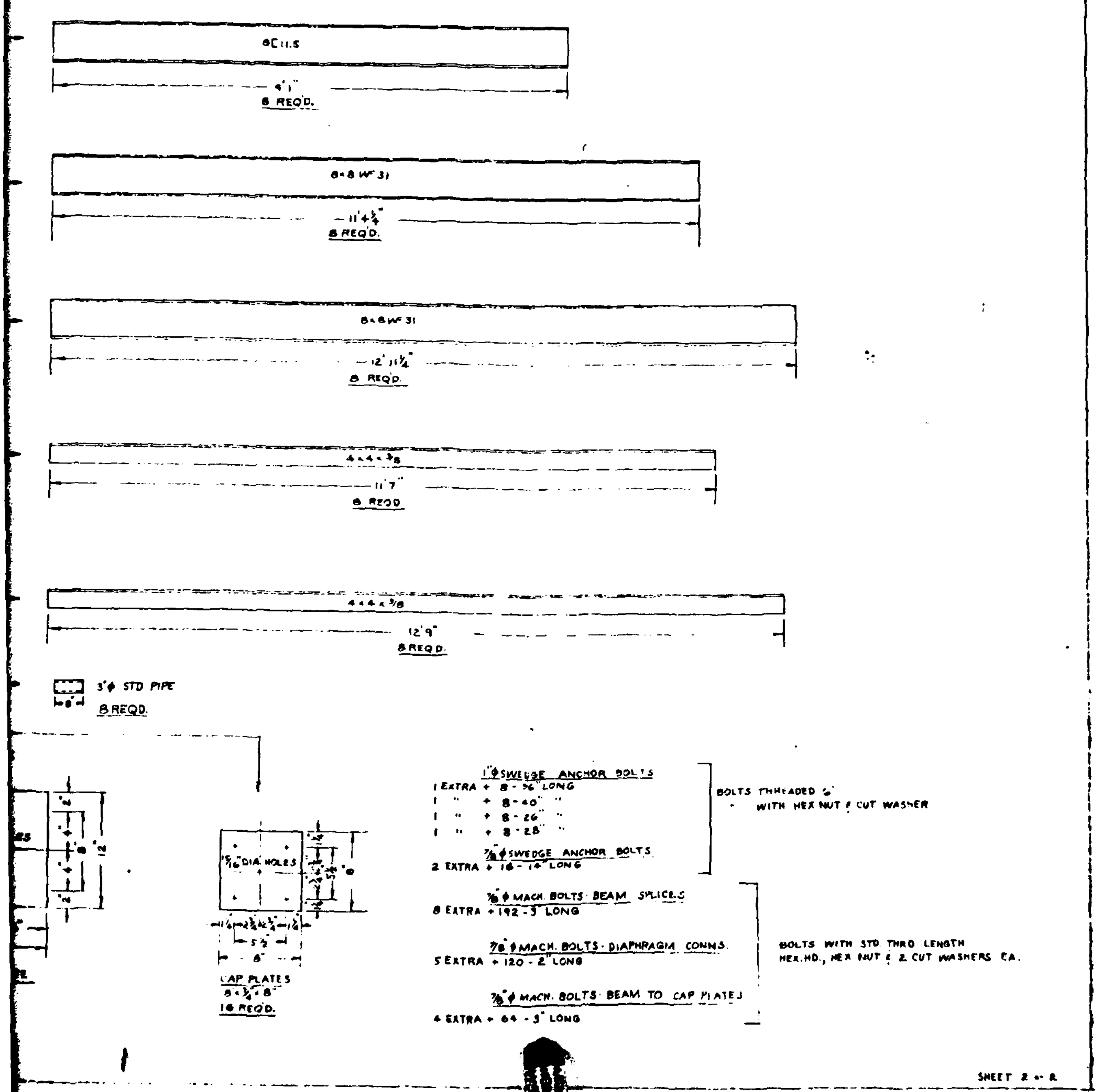
WHITMAN, REQUARDT AND ASSOCIATES — CONSULTING ENGINEERS
JULY 1967 — SHEET 3 OF 7


BEAM A
BEAM B
FACE OF SOUTH ABUTMENT
CENTER LINES OF 8 COLUMN BENTS
9 - 20' BAYS - 180'
9/16" HOLES 2 EQ SPACES 20" C to C
TOP FLANGE
ALL WEB HOLES 15/16" DIA.
21' 7 1/2"
BOTTOM FLANGE
12 WF 40 MK BEAM 'A' 4 REQD.
9/16" HOLES 11 EQ SPACES 20" O.C.
TOP FLANGE
ALL WEB HOLES 15/16" DIA.
19' 11 1/2"
15/16" DIA HOLES
BOTTOM FLANGE
12 WF 40 MK BEAM 'B' 14 REQD.
1/2" SPLICE PLATES
32 REQD.
15/16" DIA HOLES
15/16" DIA HOLES
9/16" SHIM PLATE
8 REQD.


TYP BRACKET LOCATION
BEAM "A"
9'8 TO C OF BEAMS (STRINGERS)
FACE OF NORTH ABUTMENT
10 C 15.3
ALL WEB HOLES 15/16" DIA.
DIAPHRAGM BEAM
8'10 5/8" MK "C" 8 REQ'D. AT COLUMN BENTS
8'11 5/8" MK "D" 11 REQ'D. BETWEEN COLUMN BENTS
15/16" DIA HOLES
LEFT LEG
RIGHT LEG
4 x 4 x 3/8 L
16 REQ'D.
(AT COLUMN BENTS)
4 x 4 x 3/8 L
22 REQ'D.
(BETWEEN COLUMN BENTS)
15/16" DIA HOLES
9/16" DIA HOLES
PLAN VIEW
END VIEW
SIDE VIEW
TYP. ABUTMENT BRACKET
4 REQ'D.
NOTE
FULL SHOP WELDED CONSTRUCTION ON BRACKETS.
BRACKET PIECES REQ'D.
NO. PCS. SIZE
4 2'0" x 1'7 1/2" x 1" PLATE - DRILLED
4 1'7 1/2" x 1'3 1/2" x 3/4"
8 1'11 1/4" x 1'3 1/2" x 3/4" RT. △ PLATE
NOTE: SHOP PAINT 1 COAT RED LEAD ALL MATERIAL ON THIS SHEET
15/16" DIA HOLES
3/4" CLAMP PLATE 8 REQ'D.
(AT ABUTMENT BRACKETS)
BOY SCOUT DAM ON BROAD CREEK
BRIDGE
STRUCTURAL STEEL DWG.
TO BE ERECTED BY NRCB DIV F-4
BALTIMORE, MD.
OCTOBER 22, 1965
1 OF 2
C-8



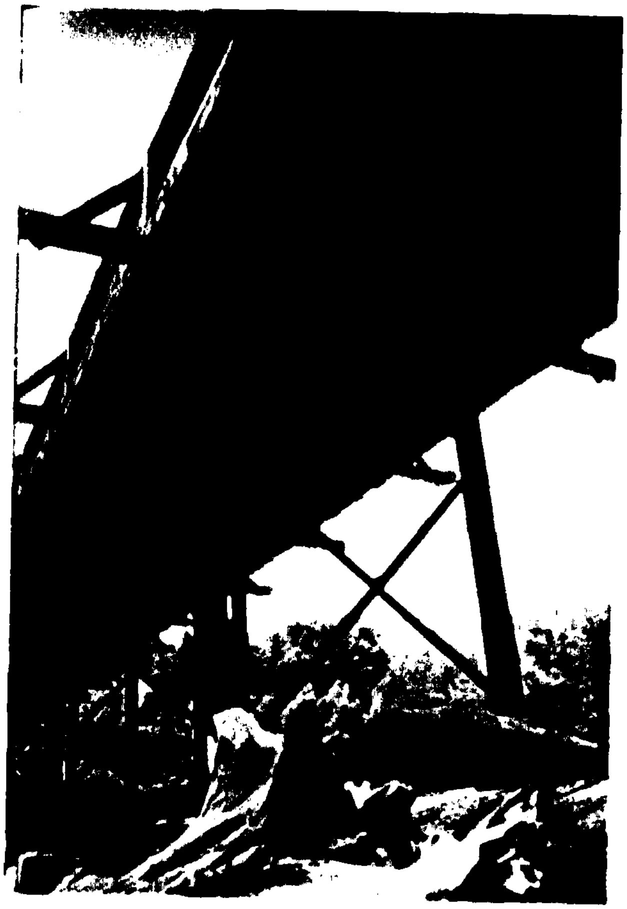
NOTE.
FULL SHOP WELDED CONSTRUCTION
SHOP PAINT 1 COAT RED LEAD


8[11.5
9'1"
8 REQ'D.
8×8 WF 31
11'4¼"
8 REQ'D.
8×8 WF 31
12'11¼"
8 REQ'D.
4×4×3/8
11'7"
8 REQ'D
4×4×3/8
12'9"
8 REQ'D.
3"φ STD PIPE
8 REQ'D.
5/16" DIA. HOLES
5½"
8"
CAP PLATES
8×¾×8"
16 REQ'D.
1"φ SWEDGE ANCHOR BOLTS
1 EXTRA + 8 - 36" LONG
1 " + 8 - 40" "
1 " + 8 - 26" "
1 " + 8 - 28" "
7/8"φ SWEDGE ANCHOR BOLTS
2 EXTRA + 16 - 14" LONG
BOLTS THREADED 6"
WITH HEX NUT & CUT WASHER
7/8"φ MACH. BOLTS · BEAM SPLICES
8 EXTRA + 192 - 3" LONG
7/8"φ MACH. BOLTS · DIAPHRAGM CONNS.
5 EXTRA + 120 - 2" LONG
7/8"φ MACH. BOLTS · BEAM TO CAP PLATES
4 EXTRA + 64 - 3" LONG
BOLTS WITH STD THRD LENGTH
HEX.HD., HEX NUT & 2 CUT WASHERS EA.
SHEET 2 of 2

APPENDIX D

PHOTOGRAPHS

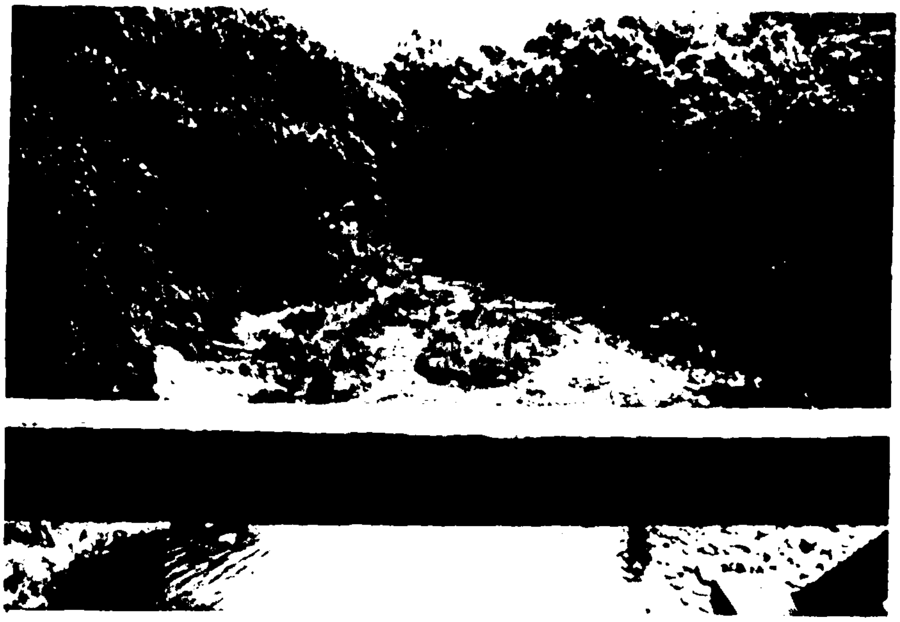
DAM CREST



BRIDGE OVER SPILLWAY

SPILLWAY FACE &
DRAIN OUTLET

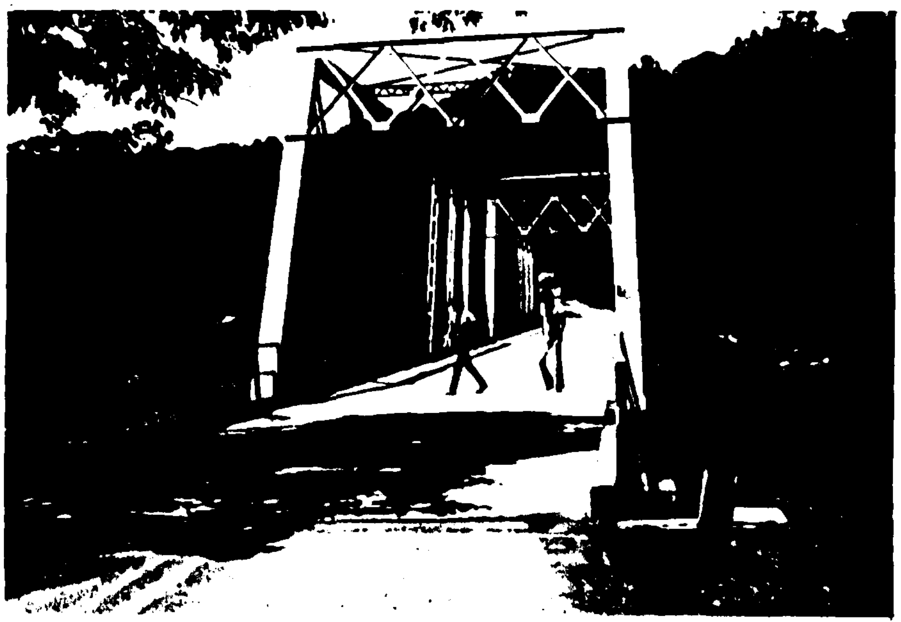
DOWNSTREAM FACE



DOWNSTREAM VIEW

RIGHT ABUTMENT
WINGWALL UNDERMINING

DWELLINGS
2500 FEET DOWNSTREAM



MD. ROUTE 623
BRIDGE 1 MILE DOWNSTREAM

APPENDIX E

HYDROLOGY, HYDRAULICS, AND STRUCTURAL ANALYSES

Table of Contents

Broad Creek Dam
N.D.I MD 00017

Snyder's Unit Hydrograph Coefficients

L = 12.5 miles L_{ca} = 5.6 miles

from Baltimore District plates, Broad Creek Watershed in Zone 36-A

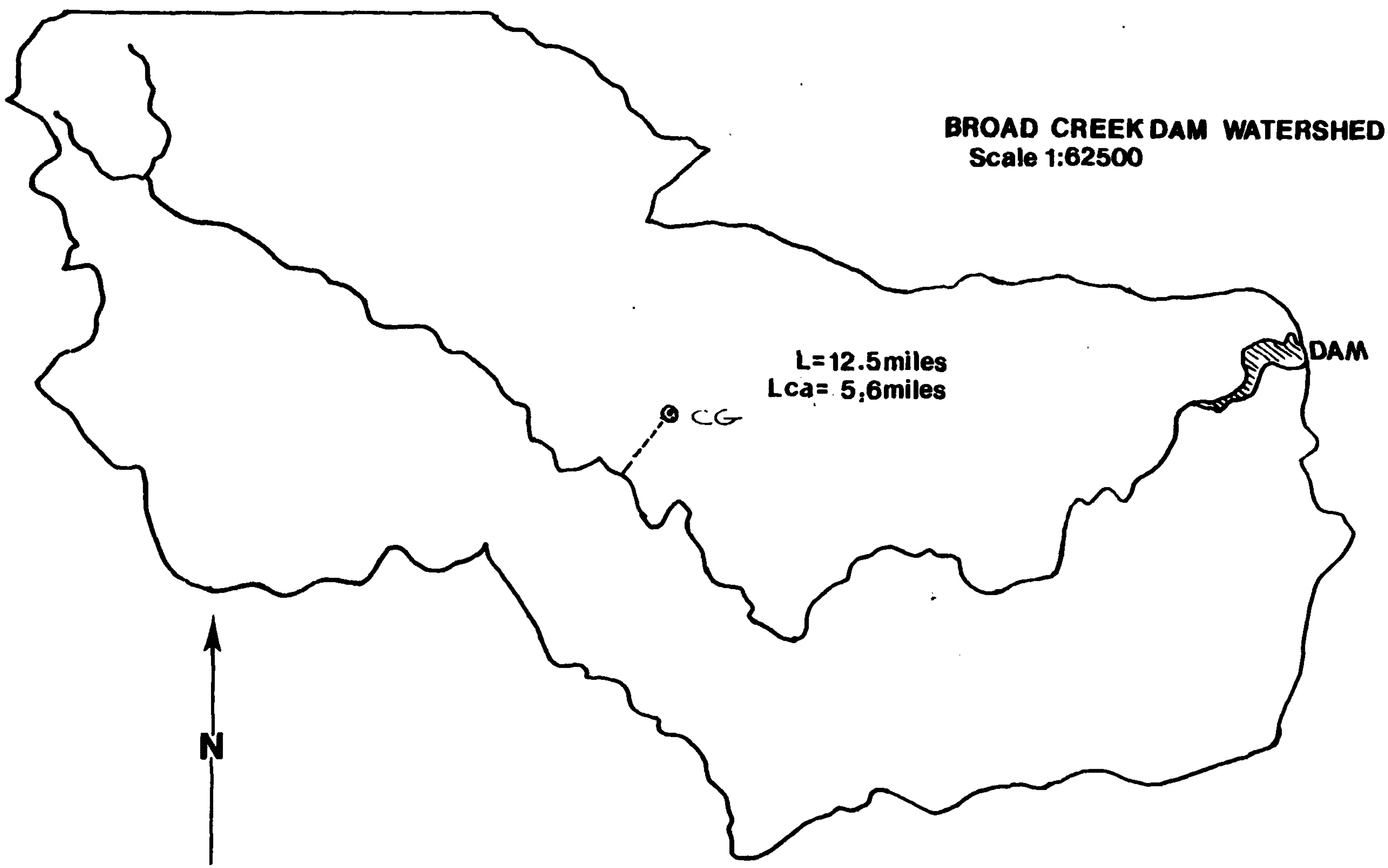
$L_{ag}\ t_p = C_t (L \times L_{ca})^{0.3} = 1.37 (12.5 \times 5.6)^{0.3}$
$= 4.7$ hours

$t_r = \frac{t_p}{5.5} = \frac{4.7}{5.5} = 0.9$ hrs.

use 1 hr [illegible] minutes on B CARD

Precipitation
from Hydromet [illegible] Zone [illegible]

Index Precip = 23.[illegible] inches
R_6 – [illegible] %
[illegible] – [illegible] %
[illegible] – [illegible] %


BROAD CREEK DAM WATERSHED
Scale 1:62500
DAM
L=12.5miles
Lca= 5,6miles
CG
N

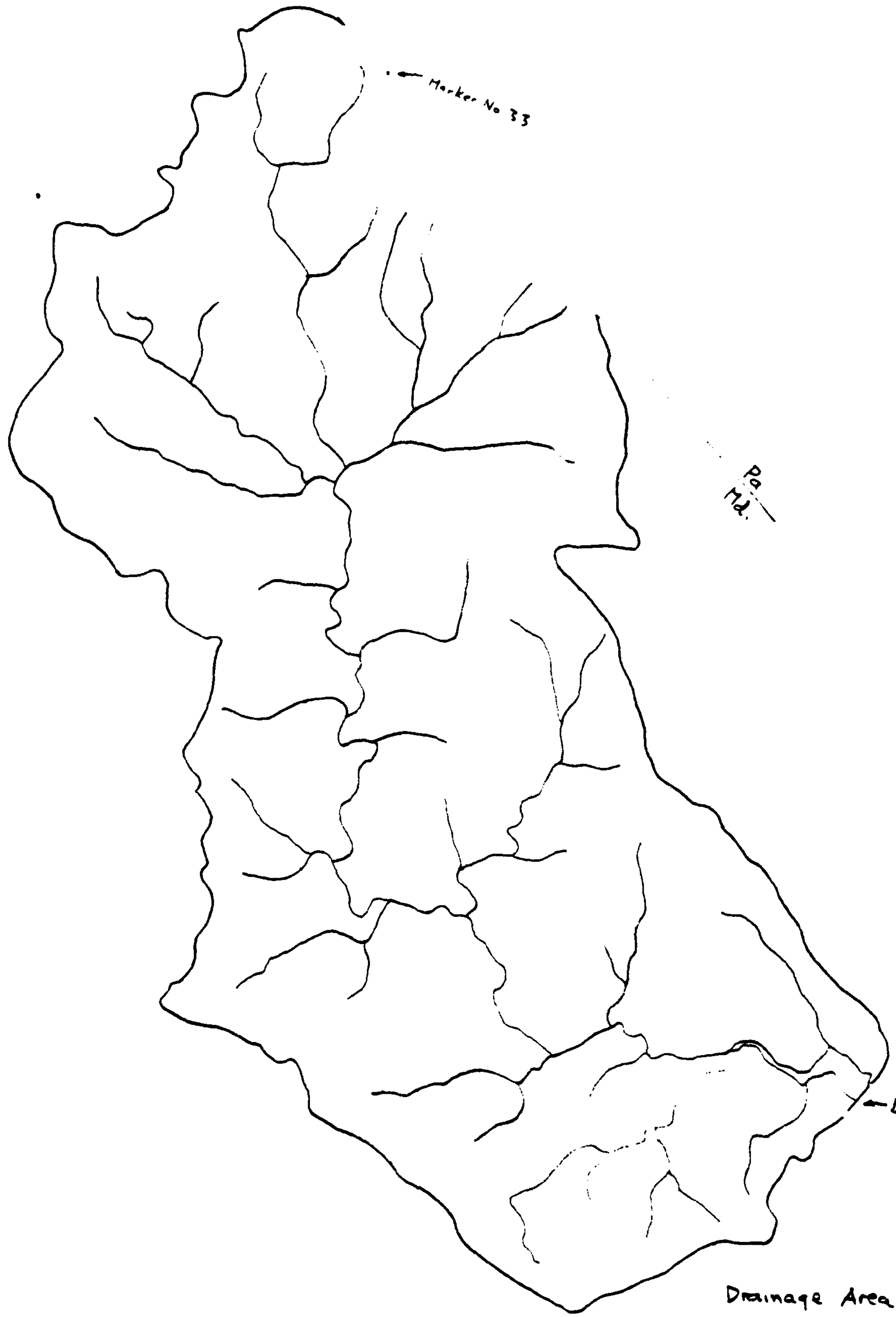
Stage - Surface Area

from surveyed (1979 Water Resources) data,
(plunge pool) streambed at dam = 153.61 ft. Report Datum
gated drain invert = 159
from 1:24000 Quad Sheet, Area of Normal Pool (elev. 178) = 40.17 Ac
from 1:24000 Quad Sheet Area @ elev. 200 = 121.96 Ac.

\$A	Surface Area	0	40.17	121.96
\$E	Stage	159	178	200

Drainage Area

from 1:62500 County Topo Map drainage area =
30.99 square miles



Drainage Area Map

31.85 in² = 19,834 Ac from Harford Co. topo map
= 30.99 mi² 1:62500

E-5

Tailwater on Ogee Spillway

Using downstream X-Section to establish normal depth parameters

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

Assuming $n = 0.04$
$S = S_0$ = regional slope

X-section 252 Ft. downstream from dam
streambed elev. = 162.2

X-section 3500 Ft. upstream of Rt. 623
streambed elev = 102.6
bridge (9000 Ft. downstream from dam)

elev. difference = 162.2 − 102.6 = 59.6 ft

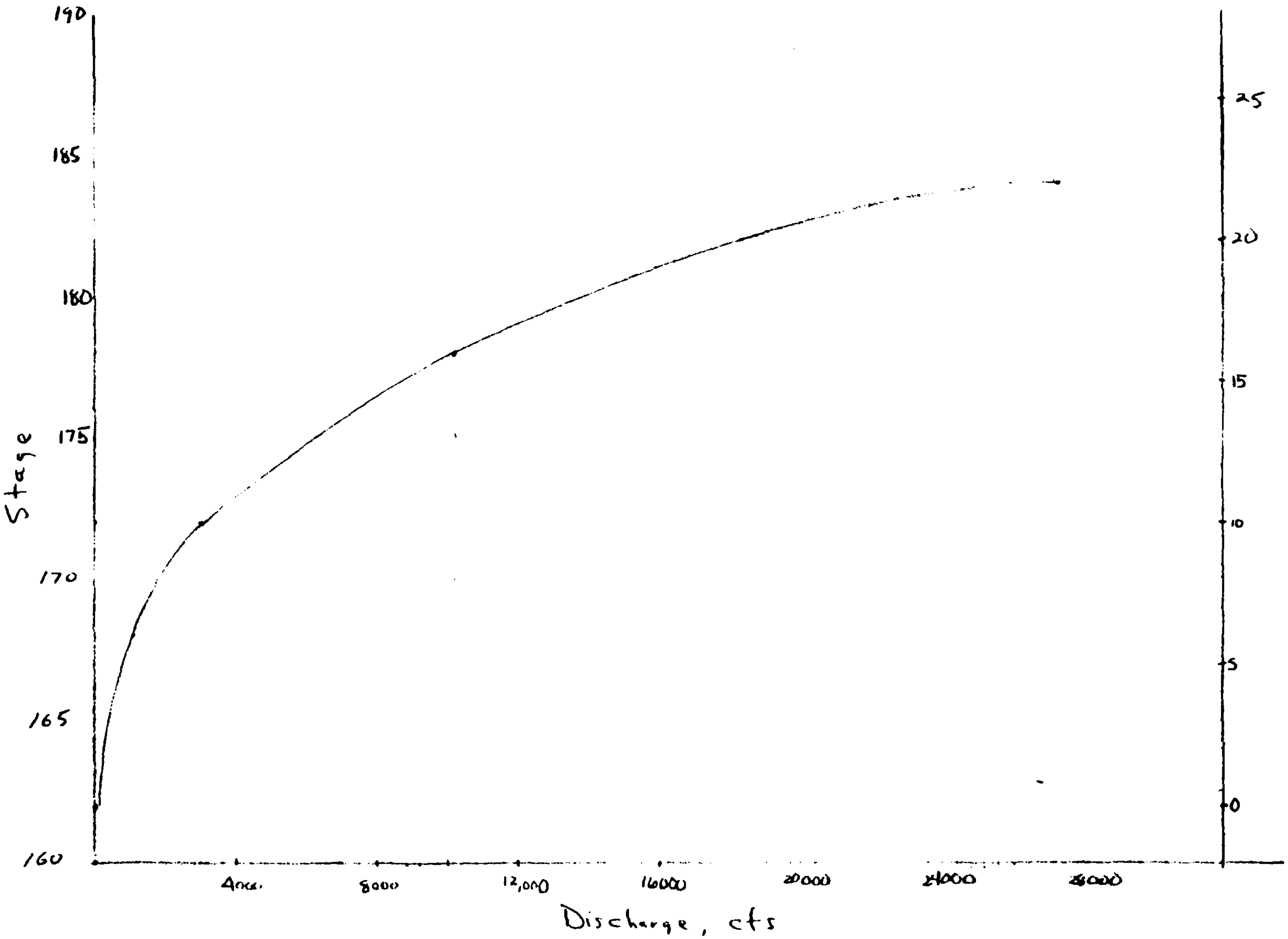
length between sections = 9000 − 252 = 8748 ft.

regional slope = 59.6/8748 = 0.0068 ft/ft.

use S = 0.0068 ft/ft.

$$Q = \frac{1.49}{0.04}(0.0068)^{1/2} AR^{2/3} = 3.07\, AR^{2/3}$$

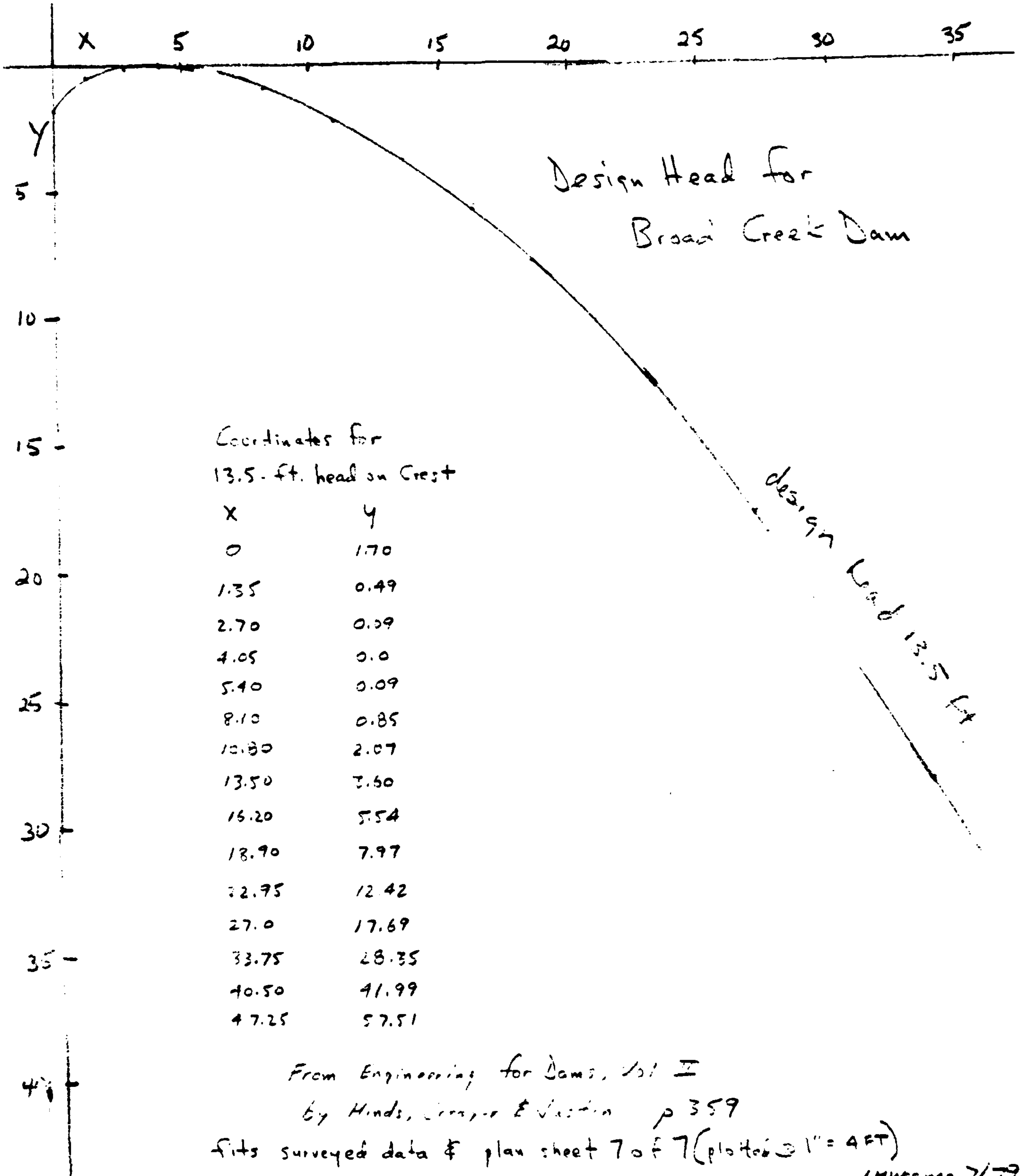
Stage	Depth ft	Area ft²	W.Perimeter	R	$R^{2/3}$	Q cfs
162	0	0				0
168	6	152	44	3.45	2.29	1069
172	10	360	76	4.74	2.84	3139
178	16	956	136	7.03	3.69	10830
184	22	1884	186	10.13	4.72	27300
190	28	3076	220	+13.98	5.86	55338



Rating Curve - Downstream from Broad Creek Dam

standard ogee crest upstream face vertical

Plot of Lower Nappe and Downstream Face of Dam



Coordinates for
13.5-ft. head on Crest

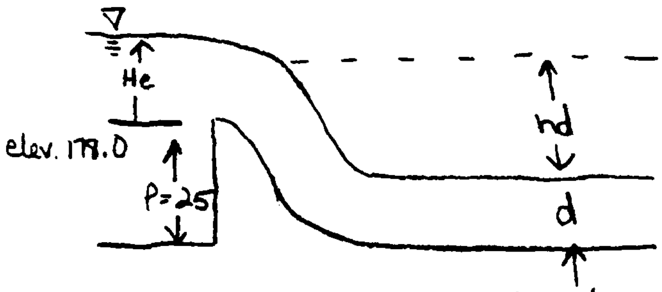
X	Y
0	1.70
1.35	0.49
2.70	0.09
4.05	0.0
5.40	0.09
8.10	0.85
10.80	2.07
13.50	3.60
16.20	5.54
18.90	7.97
22.95	12.42
27.0	17.69
33.75	28.35
40.50	41.99
47.25	57.51

From Engineering for Dams, Vol II
by Hinds, Creager & Justin p 359
fits surveyed data & plan sheet 7 of 7 (plotted @ 1" = 4 FT)

J M Wagner 7/79

Rating Curve for Ogee

using fig. 249, 250, 252 from Design of Small Dams



H_o = design head = 13.5 feet

H_e = head under consideration

@ Pool elev. 178.0, $H_o = 13.5$, $H_e = 0$, $d = 0$, $hd = 25$, $P = 25$

$Q = 0$ cfs

@ Pool elev. 180.0, $H_o = 13.5$, $H_e = 2$, $P = 25$

$P/H_o = 1.85$ $\therefore C_o = 3.93$ fig. 249

$H_e/H_o = 0.15$ $\therefore C/C_o = 0.84$ fig. 250

$\therefore C = 0.84(3.93) = 3.3$

$Q = CLH_e^{3/2} = 3.3 \times 180 \times 2^{3/2} = 1680$ cfs

from Tailwater Rating Curve @ 1680 cfs, $d = 7.5$, $hd = 27 - d = 19.5$

$$\left.\begin{aligned} \frac{hd + d}{H_e} &= 13.5 \\ \frac{hd}{H_e} &= 9.75 \end{aligned}\right\} \text{no reduction in } C$$

USE $Q = 1680$ cfs

@ Pool elev. 182, $H_o = 13.5$, $He = 4$, $P = 25$, $C_o = 3.93$

$He/H_o = 0.3$ $\therefore C/C_o = 0.88$

$\therefore C = 0.88 \times 3.93 = 3.46$

$Q = CLHe^{3/2} = 3.46 \times 180 \times 4^{3/2} = 4982$ cfs

from Tailwater Rating Curve @ 4982 cfs, $d = 11.8$, $hd = 29 - d = 17.2$

$$\left.\begin{array}{l} \dfrac{hd + d}{He} = 7.25 \\ \\ \dfrac{hd}{He} = 4.30 \end{array}\right\} \text{no reduction in } C$$

USE $Q = 4982$ cfs

@ Pool elev. 184, $H_o = 13.5$, $He = 6$, $P = 25$, $C_o = 3.93$

$He/H_o = 0.44$ $\therefore C/C_o = 0.91$

$\therefore C = 0.91 \times 3.93 = 3.58$

$Q = CLH_e^{3/2} = 3.58 \times 180 \times 6^{3/2} = 9471$ cfs

from Tailwater Rating Curve @ 9471 cfs, $d = 15.5$, $hd = 31 - d = 15.5$

$$\left.\begin{array}{l} \dfrac{hd + d}{He} = 5.17 \\ \\ \dfrac{hd}{He} = 2.58 \end{array}\right\} \text{no reduction in } C$$

Use $Q = 9471$ cfs

@<u>Pool elev. 186</u>, $H_o = 13.5$, $H_e = 8$, $P = 25$, $C_o = 3.93$

$H_e/H_o = 0.59 \quad \therefore C/C_o = 0.94$

$\therefore C = 0.94 \times 3.93 = 3.69$

$Q = CLH_e^{3/2} = 3.69 \times 180 \times 8^{3/2} = 15029\ cfs$

from Tailwater Rating Curve @ 15029 cfs, $d = 18.5$, $hd = 33 - d = 14.5$

$$\left.\begin{array}{l} \dfrac{hd + d}{He} = 4.13 \\[2ex] \dfrac{hd}{He} = 1.81 \end{array}\right\} \text{no reduction in } C$$

<u>USE Q = 15029 cfs</u>

@<u>Pool elev. 188</u>, $H_o = 13.5$, $H_e = 10$, $P = 25$, $C_o = 3.93$

$H_e/H_o = 0.74 \quad \therefore C/C_o = 0.96$

$\therefore C = 0.96 \times 3.93 = 3.77$

$Q = CLH_e^{3/2} = 3.77 \times 180 \times 10^{3/2} = 21459\ cfs$

from Tailwater Rating Curve @ 21459 cfs, $d = 21$, $hd = 35 - d = 14$

$$\left.\begin{array}{l} \dfrac{hd + d}{He} = 3.50 \\[2ex] \dfrac{hd}{He} = 1.40 \end{array}\right\} \text{no reduction in } C$$

<u>USE Q = 21459 cfs</u>

@ Pool elev 190, $H_o = 13.5$, $He = 12$, $P = 25$, $C_o = 3.93$

$$He/H_o = 0.89 \quad \therefore C/C_o = 0.985$$

$$\therefore C = 0.985 \times 3.93 = 3.87$$

$$Q = CLHe^{3/2} = 3.87 \times 180 \times 12^{3/2} = 28957 \text{ cfs}$$

from Tailwater Rating Curve @ 28957 cfs, $d = 22$, $hd = 37 - d = 15$

$$\left.\begin{aligned} \frac{hd + d}{He} &= 3.08 \\ \frac{hd}{He} &= 1.25 \end{aligned}\right\} \text{no reduction in } C$$

USE Q = 28957 cfs

@ Pool elev. 196, $H_o = 13.5$, $He = 18$, $P = 25$, $C_o = 3.93$

$$He/H_o = 1.33 \quad \therefore C/C_o = 1.04$$

$$\therefore C = 1.04 \times 3.93 = 4.09$$

$$Q = CLHe^{3/2} = 4.09 \times 180 \times 18^{3/2} = 56222 \text{ cfs}$$

from Tailwater Rating Comps @ 56222 cfs, $d = 28$, $hd = 43 - d = 15$

$$\left.\begin{aligned} \frac{hd + d}{He} &= 2.39 \\ \frac{hd}{He} &= 0.83 \end{aligned}\right\} \text{no reduction in } C$$

USE Q = 56222 cfs

SUMMARY

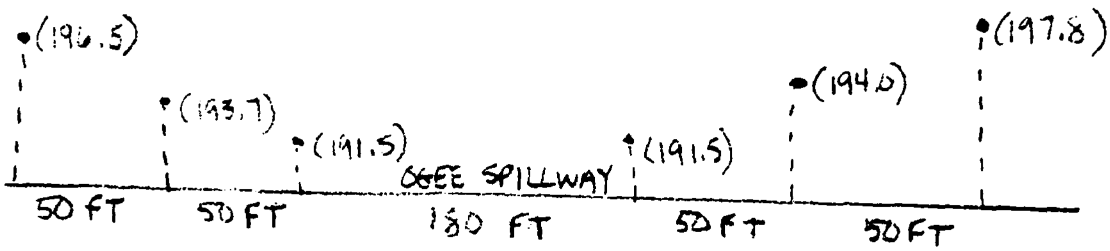
stage, ft MSL	Discharge, cfs
178	0
180	1680
182	4982
184	9471
186	15029
188	21459
190	28957
196	56222

Y^4 ——— CARDS ——— Y^5

Non-Level Dam Crest

from 1979 W.R.A. Survey

SKETCH



200 FT CREST LENGTH (NOT INCLUDING SPILLWAY)

$L	0	2	103	135	165	195	225
$V	190.0	191.5	194.0	195.0	196.0	197.0	198.0

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
LAST MODIFICATION  26 FEB 79
**********************************
    1          A1     SNYDER UNIT HYDROGRAPH,FLOOD ROUTING,AND DAM OVERTOPPING ANALYSIS
               A2     BROAD CREEK DAM, HARFORD COUNTY, MD. N.D.I.  MD00017
    3          A3     FOR VARIOUS PERCENTAGES OF PMF
    4          B     200       1       0       0       0       0       0       0      -4       0
    5          B1      5
    6          J       1       9       1
    7          J1     .1      .2      .3      .4      .5      .6      .7      .8      1.
    8          K       0       1                                       1
    9          K1      CALCULATION OF INFLOW TO BROAD CREEK DAM
   10          M       1       1   30.99           30.99                                   1
   11          P            23.8     102     112     121
   12          T                                                       1     .05
   13          W    4.94    0.62
   14          X    -1.5   -0.05      2.
   15          K       1       2                                       1
   16          K1      ROUTED FLOWS THROUGH LAKE STRAUS
   17          Y                               1       1
   18          Y1      1                                            -178      -1
   19          Y4    178     180     182     184     186     188     190     196
   20          Y5      0    1680    4982    9471   15029   21459   28957   56222
   21          $A      0   40.17  121.96
   22          $E    159    178.    200.
   23          $$ 178.0
   24          $D 190.0     3.1     1.5     200
   25          $L      0       2     103     135     165     195     225
   26          $V    190   191.5     194     195     196     197     199
   27          K      99
                         PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                              RUNOFF HYDROGRAPH AT          1
                              ROUTE HYDROGRAPH TO           2
                              END OF NETWORK
```

```
                SNYDER UNIT HYDROGRAPH.FLOOD ROUTING AND DAM OVERTOPPING ANALYSIS
                BROAD CREEK DAM, HARFORD COUNTY, MD. N.D.I.  MD00017
                FOR VARIOUS PERCENTAGES OF PMF

                                    JOB SPECIFICATION
       NQ     NHR     NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
      200       1        0       0       0       0       0       0      -4       0
                                 JOPER    NWT   LROPT   TRACE
                                     5      0       0       0

                            MULTI-PLAN ANALYSES TO BE PERFORMED
                                 NPLAN= 1 NRTIO= 9 LRTIO= 1
          RTIOS=    .10    .20    .30    .40    .50    .60    .70    .80   1.00


 **********         **********         **********         **********         **********

                                 SUB-AREA RUNOFF COMPUTATION

             CALCULATION OF INFLOW TO BROAD CREEK DAM

                       ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                           1       0       0       0       0       0       1       0       0

                                       HYDROGRAPH DATA
           IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
               1       1   30.99    0.00   30.99    0.00   0.000       0       1       0

                                        PRECIP DATA
                      SPFE     PMS      R6     R12     R24     R48     R72     R96
                      0.00   23.80  102.00  112.00  121.00    0.00    0.00    0.00
 TRSPC COMPUTED BY THE PROGRAM IS  .836

                                        LOSS DATA
         LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
             0    0.00    0.00    1.00    0.00    0.00    1.00    1.00     .05    0.00    0.00

                                   UNIT HYDROGRAPH DATA
                              TP=  4.94     CP= .82     NTA=  0
```

```
                                    RECESSION DATA
                    STRTQ=   -1.50    QRCSN=    -.05    RTIOR= 2.00

          UNIT HYDROGRAPH 15 END-OF-PERIOD ORDINATES, LAG=   4.91 HOURS, CP= .81  VOL= 1.00
       326.      1118.     2038.     2852.     3293.     3232.     2666.     1792.     1673.      642.
       334.       230.      138.       82.       49.

        0                                END-OF-PERIOD FLOW
   MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS   COMP Q       MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS    COMP Q

                                                                              SUM  24.08  22.23   1.86   480242
                                                                                 ( 612.)( 565.)( 47.)(13598.94)


        **********        **********        **********        **********        **********

                                       HYDROGRAPH ROUTING

                   ROUTED FLOWS THROUGH LAKE STRAUS

                             ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                                 2       1       0       0       0       0       1       0       0
                                                 ROUTING DATA
                        QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP            LSTR
                          0.0   0.000    0.00       1       1       0       0               0

                             NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                                 1       0       0   0.000   0.000   0.000   -178.      -1

  STAGE      178.00     180.00     182.00     184.00     186.00     188.00     190.00     196.00

   FLOW        0.00    1680.00    4982.00    9471.00   15029.00   21459.00   28957.00   56222.00

SURFACE AREA=       0.        40.       122.

   CAPACITY=        0.       254.      1957.

  ELEVATION=      159.       178.       200.

                          CREL    SPWID    COQW    EXPW    ELEVL    COQL    CAREA    EXPL
                         178.0      0.0     0.0     0.0      0.0     0.0      0.0     0.0

                                                   DAM DATA
                                          TOPEL    COQD    EXPD   DAMWID
                                          190.0     3.1     1.5     200.

  CREST LENGTH       0.         2.        163.       135.       165.       195.       225.
  AT OR BELOW
  ELEVATION        190.0      191.5      194.0      195.0      196.0      197.0      198.0
```

```
PEAK OUTFLOW IS     5764. AT TIME  20.00 HOURS

PEAK OUTFLOW IS    11518. AT TIME  20.00 HOURS

PEAK OUTFLOW IS    17283. AT TIME  20.00 HOURS

PEAK OUTFLOW IS    23037. AT TIME  20.00 HOURS

PEAK OUTFLOW IS    28748. AT TIME  20.00 HOURS

PEAK OUTFLOW IS    34623. AT TIME  20.00 HOURS

PEAK OUTFLOW IS    40281. AT TIME  20.00 HOURS

PEAK OUTFLOW IS    46083. AT TIME  20.00 HOURS

PEAK OUTFLOW IS    52692. AT TIME  20.00 HOURS

          **********   **********   **********   **********   **********
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .10	RATIO 2 .20	RATIO 3 .30	RATIO 4 .40	RATIO 5 .50	RATIO 6 .60	RATIO 7 .70	RATIO 8 .80	RATIO 9 1.00
HYDROGRAPH AT	1	30.99	1	5814.	11627.	17441.	23254.	29068.	34882.	40695.	46509.	58136.
	(	80.26)	(	164.62)(	329.25)(	493.87)(	658.49)(	823.11)(	987.74)(	1152.36)(	1316.98)(	1646.23)
ROUTED TO	2	30.99	1	5764.	11518.	17283.	23037.	28748.	34623.	40281.	46083.	57692.
	(	80.26)	(	163.23)(	326.16)(	489.39)(	652.34)(	814.05)(	980.40)(	1140.63)(	1304.91)(	1633.65)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	178.00	178.00	190.00
STORAGE	254.	254.	958.
OUTFLOW	0.	0.	28957.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	182.35	0.00	456.	5764.	0.00	20.00	0.00
.20	184.74	0.00	591.	11518.	0.00	20.00	0.00
.30	186.70	0.00	717.	17283.	0.00	20.00	0.00
.40	188.42	0.00	837.	23037.	0.00	20.00	0.00
.50	189.94	0.00	954.	28748.	0.00	20.00	0.00
.60	191.25	1.25	1060.	34623.	4.00	20.00	0.00
.70	192.48	2.48	1167.	40281.	4.00	20.00	0.00
.80	193.69	3.69	1277.	46083.	6.00	20.00	0.00
1.00	195.89	5.89	1494.	57692.	6.00	20.00	0.00

[illegible] CREEK DAM   MD 00017   7-27-79

CHECK STABILITY OF DAM FOR MAXIMUM SECTION:

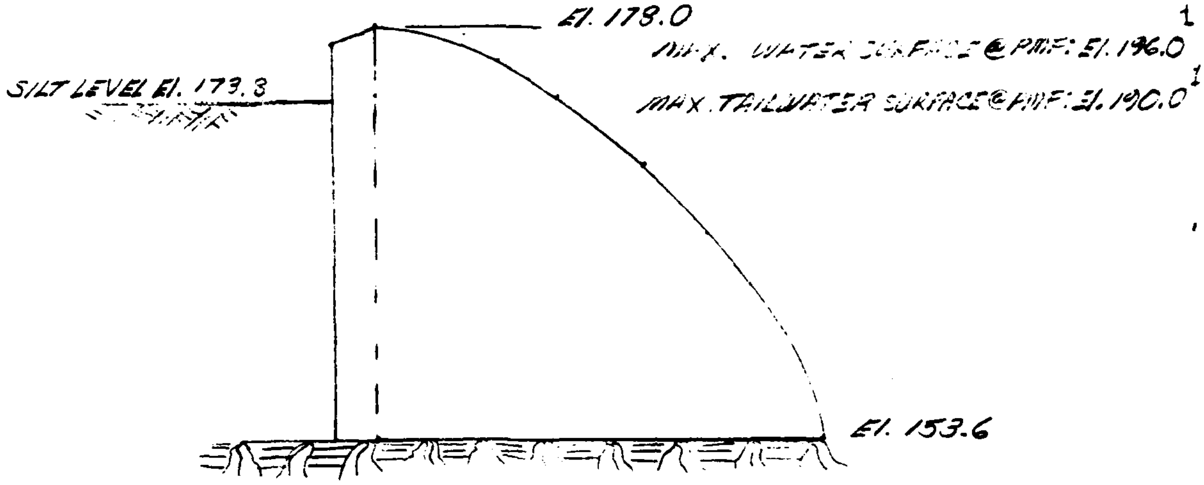


FIG. 1. SECTION STA. 1+42

STABILITY DATA[2]:

H = maximum depth of water to be retained @ PMF = 42.4 ft.

h_2 = depth of tailwater @ PMF = 36.4 ft.

h_c = spillway crest to maximum water surface = 18 ft.

w_1 = weight of masonry = 150 pcf

w_2 = weight of water = 62.5 p.c.f.

c = uplift area factor = 1.0

ρ = uplift intensity factor = 0.67

P_i = ice pressure : thickness = 3.0 ft

temperature rise = 4°F/hr for 12 hrs.

f = allowable coefficient of friction for joint at base = 0.70

h_s = height of silt = 20.2 ft., $\phi_s = 25°$, $\gamma_{dr.} = 100$ pcf

$e = .40$, $G_s = 2.67$, $K_A = .41$

[1] REFER TO SECTION [illegible], HYDROLOGY AND HYDRAULICS [illegible]

[2] SEE REFERENCE 1 FOR STABILITY DATA [illegible] ANALYSIS

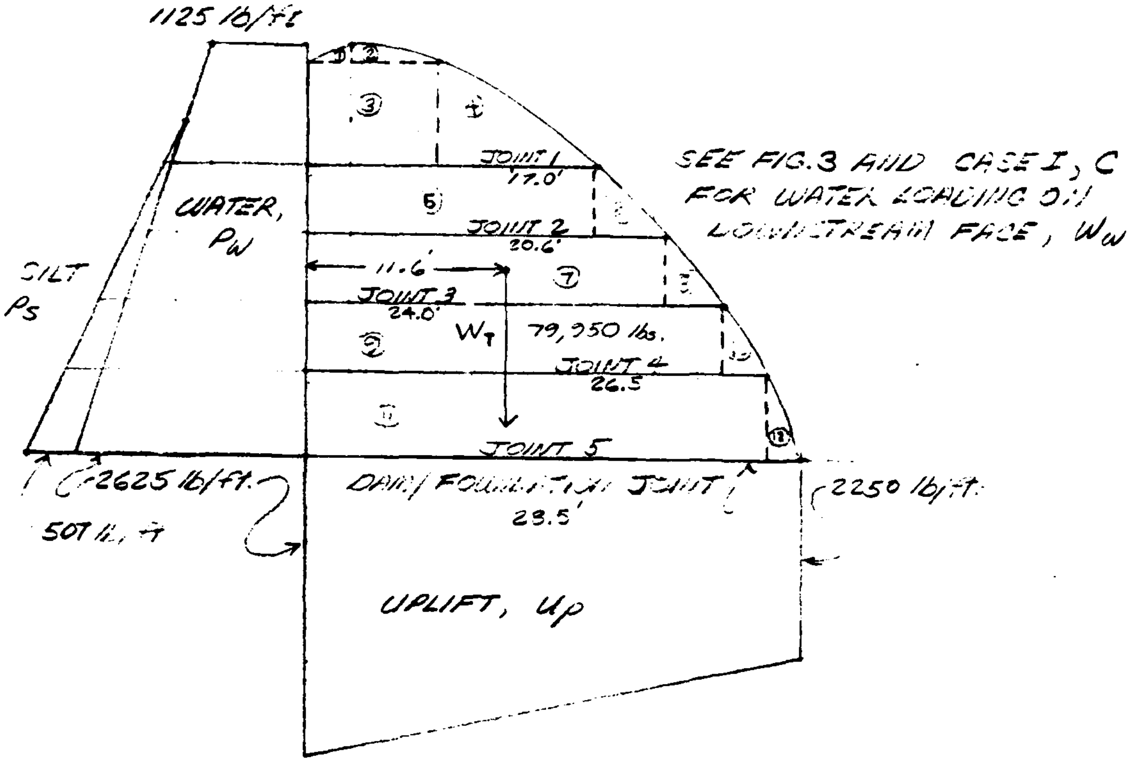


FIG.2. LOADING CONDITION: CASE I

CASE I : DETERMINE STABILITY OF DAM FOR PMF LOADING, SILT, NO ICE.

A. DETERMINE SILT LOAD:

$p_s = K_A \gamma (sub)$

$K_A = \frac{1-\sin\phi}{1+\sin\phi} = .41$

$\gamma_{SUB} = \gamma_{SAT} - W_2$

$\gamma_{SAT} = \gamma_{dry} + e\,W_2 = 125\ PCF$

$\gamma_{SUB} = 62.5\ PCF$

$p_s = .41\ (62.5) = 25.6\ psf$

[illegible] MDO [illegible] 7-27-79

B. [illegible]:

TABLE 1

CONSTR. UNIT NO.	AREA NO.	X FT	Y FT	WGT. lbs	ARM* $\bar{x}$	MOMENT FT-lbs.
1	1	2.5	1.0	375	1.67	626.2
	2	5.0	1.0	750	6.67	5002.5
	3	7.5	6.0	6750	3.75	25312.5
	4	9.0	6.0	8100	10.50	85050.0
				15975 — SUBTOTAL		115991
2	5	16.5	4.0	9900	8.25	81675.0
	6	4.0	4.0	2400	17.33	42792.0
				28275 — SUBTOTAL		240459
3	7	20.5	4.0	12300	10.25	126075.0
	8	3.5	4.0	2100	21.67	45507.0
				42,675 — SUBTOTAL		412040
4	9	24.0	4.0	14,400	12.00	172800.0
	10	2.5	4.0	1500	24.83	37245.0
				58575 — SUBTOTAL		622085
5	11	26.5	5.0	19875	13.25	263343.8
	12	2.0	5.0	1500	27.17	40755.0
TOTAL				79950	(11.53)	926,184

* ORIGIN AT UPSTREAM FACE OF DAM

C. DETERMINE FORCES ACTING ON SPILLWAY: (SEE FIG)

ZONE	F_V (lbs.)	F_H (lbs.)	RESULTANT (lbs.)
W1a	(2.5)(18.0)(62.5) = 2812	0	2812 ∠90°
W1b	(7.5)(18.8)(62.5) = 8812	(2.5)(18.8)(62.5) = 2935	9289 ∠71.6°
W1c	(7.0)(20.4)(62.5) = 8925	(4.6)(20.4)(62.5) = 5865	10680 ∠56.7°
W2	(3.7)(22.6)(62.5) = 5226	(4.0)(22.6)(62.5) = 5650	7696 ∠42.8°
W3	(3.3)(25.8)(62.5) = 5321	(4.0)(25.8)(62.5) = 6450	8362 ∠39.5°
W4	(2.5)(29.2)(62.5) = 4562	(4.0)(29.2)(62.5) = 7300	8608 ∠32.0°
W5	(2.0)(33.7)(62.5) = 4212	(5.0)(33.7)(62.5) = 10531	11342 ∠26.6°

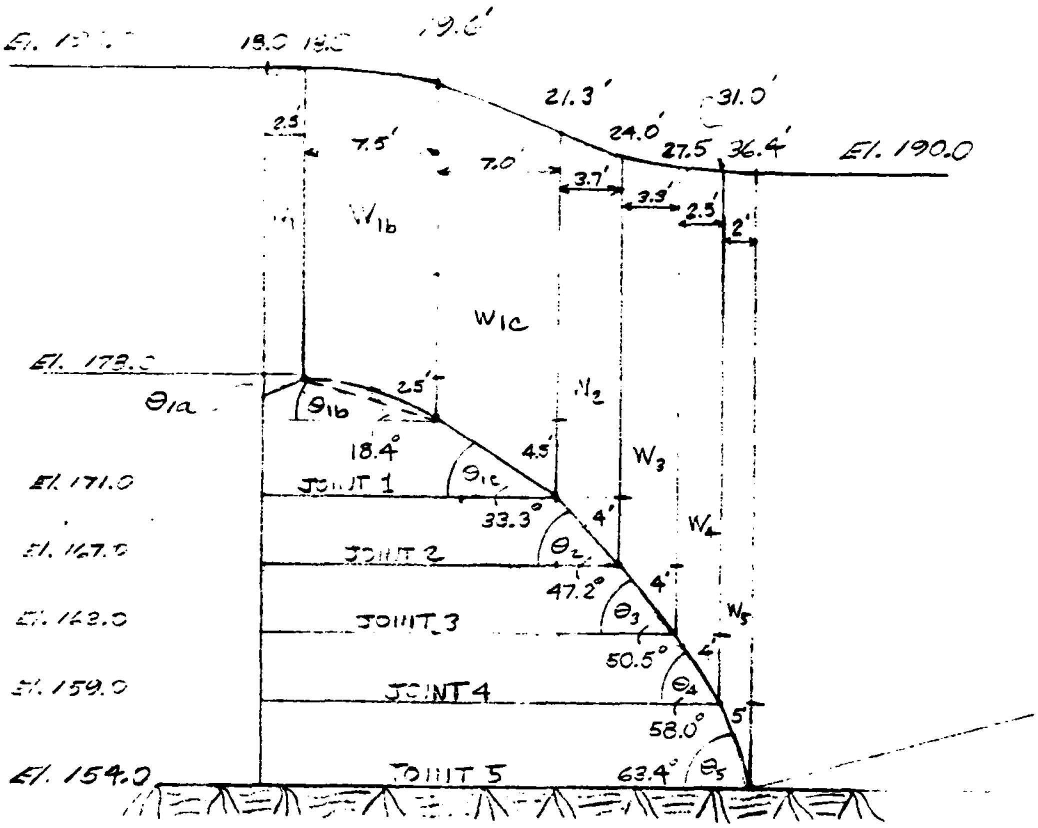


FIG. 3 ESTIMATED PMF WATER SURFACE PROFILE

BROAD CREEK DAM   MD 00017   7-27-79

D. TENSION, OVERTURNING & SLIDING ANALYSIS

JOINT 1 , L_1 = 17.0

LOAD	DESCRIPTION	FORCE (LB) HORIZ.	FORCE (LB) VERT.	LEVER* (FT)	MOMENT (FT-LB)
W_{T_1}	CONCRETE, TABLE 1		15,975	4.0	63900
Up	UPLIFT, [1188+.67(.5)(374)] 17		-22,326†	3.2	-71443
P_W	WATER $\left(\frac{1125+1062}{2}\right)$ 7	-9405		3.3	-31127
P_S	SILT $(2.5)^2(.5)(25.6)$	-80		.8	-64
W_{1a}	WATER ON SPILLWAY	0	2812	10.0	28120
W_{1b}	" " "		9289	5.1	47374
W_{1b}	" " "	2938		5.7	16747
W_{1c}	" " "		10,680	-2.2	-23496
W_{1c}	" " "	5965		2.2	13903
	TOTAL:	650	16,430	(2.6)	42,914

$TAN\ \theta = \frac{650}{16430} = .04 < f_{allow} = .70$ OK

JOINT 2 , L_2 = 20.6'

LOAD	DESCRIPTION	FORCE (LB) HORIZ	FORCE (LB) VERT	LEVER* (FT)	MOMENT (FT-LB)
W_T	CONCRETE, TABLE 1		28,275	5.2	147,030
Up	[1437+.67(.5)(375)]20.6		-32,190	3.7	-119,103
P_W	WATER $\left(\frac{1125+1812}{2}\right)$ 11	-16,154		5.1	-82,335
P_S	SILT $(25.6)(6.5)^2(.5)$	-540		2.2	-1,188

* ORIGIN AT 1/3 L FROM DOWNSTREAM FACE ALONG JOINT

† FULL UPLIFT DUE TO OPEN JOINT WOULD BE 23,375 lbs. THIS SLIGHT INCREASE IS NOT ANTICIPATED TO APPRECIABLY AFFECT THE STABILITY OF THE STRUCTURE.

[illegible] 7-27-79

D. [illegible] 2 [illegible]

LOAD	DESCRIPTION	FORCE LB. HORIZ	FORCE LB. VERT	LEVER* FT.	MOMENT FT-LB.
W1a	WATER ON SPILLWAY	0	2312	12.1	34,025
W1b			9292	7.2	[illegible]
		2933		9.3	23,792
W1c			[illegible]	-0.1	[illegible]
		[illegible]		6.2	[illegible]
W2			[illegible]	-5.0	-26,[illegible]
		5650		2.0	11,300
TOTAL		-2241	24085	(3.9)	94,466

$TAN\ \theta = \frac{2241}{24085} = .09 < .70$ OK

JOINT 3, L = 34'

LOAD	DESCRIPTION	FORCE LB. HORIZ	FORCE LB. VERT	LEVER* FT	MOMENT FT-LB
W_F	CONCRETE, TABLE 2		42675	6.3	268,852
U_P	[1638 + .47(.5)(375)] 24		-42,527	4.3	-137,166
P_W	WATER $\frac{(125+2063)}{2}$ 15	-23918		5.0	-119,590
P_S	SILT (25.6)(10.5²)(.5) -1411			3.5	4933
W1a	WATER ON SPILLWAY		2312	14.3	40,212
	" " "	0			0
W1b	" " "		9280	9.4	87,251
	" " "	2933		13.3	40,544
W1C	" " "		10380	2.1	22,4[illegible]
	" " "	5865		10.2	59,[illegible]
W2	" "		52[illegible]	-2.8	-14,[illegible]
		5650		6.0	33,[illegible]
W_3	" "		5321	-6.4	-34,054
		6450		2.0	12,900
TOTAL		-4426	32469	(3.9)	127,002

$TAN\ \theta = \frac{4426}{32469} = .14 < .75$ OK

*ORIGIN AT 1/3 L FROM DOWNSTREAM FACE ALONG JOINT

D. (CONTINUED)

JOINT 4, $L_4 = 26.5'$

LOAD	DESCRIPTION	FORCE (Lb.) HORIZ.	FORCE (Lb.) VERT.	LEVER* (Ft.)	MOMENT (Ft-Lb.)
W_T	CONCRETE, TABLE 1		58575	7.1	415,382
U_P	$[1939 + .67(.5)(374)]\,26.5$		-54,677	4.7	-256,982
P_W	WATER $\left(\frac{1125+2312}{2}\right)19$	-32652		8.4	-274,277
P_S	SILT $(25.6)(14.5)^2(.5)$	-2691		4.8	-12,917
$W1_a$	WATER ON SPILLWAY		2812	16.0	44,992
		0		-	0
W1b			9282	11.1	103,030
		2938		17.8	52,296
W1c			10,[illegible]	3.8	40,594
		5915		14.0	83,233
W2			[illegible]	-1.1	5,749
		[illegible]		10.0	56,500
W3			[illegible]	-4.7	-25,009
		6450		6.0	38,700
W4			4562	-7.6	-34,671
		7300		2.0	14,600
	TOTAL	-7140	41781	(6.0)	251,766

$$TAN\ \theta = \frac{7140}{41781} = .17 < .70$$ OK

JOINT 5, $L_5 = 28.5'$

LOAD	DESCRIPTION	FORCE (Lb.) HORIZ.	FORCE (Lb.) VERT.	LEVER* (Ft.)	MOMENT (Ft-Lb.)
W_T	CONCRETE, TABLE 1		79,950	7.4	591,630
U_P	$[2250 + .67(.5)(375)]\,28.5$		-67,705	5.0	-338,542
P_W	WATER $\left(\frac{1125+2625}{2}\right)24$	-45012		10.4	-468,[illegible]
P_S	SILT $(25.6)(19.5)^2(.5)$	-4867		6.5	-31,636

* ORIGIN AT 1/3 L FROM DOWNSTREAM FACE ALONG JOINT

BACHE CREEK DAM [illegible] 7-27-79

C. [illegible]

LOAD	DESCRIPTION	FORCE (Lb) HORIZ.	FORCE (Lb) VERT.	LEVER* Ft.	MOMENT (Ft-Lb)
W1a	WATER ON SPILLWAY		2812	17.8	50054
	"	0		—	
W1b			9232	12.8	113810
	"	2938		22.3	66986
W1C	"		10680	5.5	58740
		5865		19.2	112,608
W2	"		5226	.2	1045
		5650		15.0	84750
W3	"		5321	-3.4	-18091
		6450		11.0	70950
W4			4562	-6.3	-28741
	"	7300		7.0	51100
W5	"		4212	-8.5	35802
		10531		2.5	26328
TOTAL		-11,145	54340	(7.1)	383,344

$$\tan\theta = \frac{11{,}145}{54340} = .21 < .70 \quad \text{OK}$$

INCLINED STRESS AT BASE: $p_v = (54340)/28.5 + 54340(6)(2.35)/28.5^2 = 2850$ psf

$$p_i = p_v \sec^2\phi - p_n \tan^2\phi = 2850\sec^2 26.6^\circ - 62.5(33.5)\tan^2 26.6$$

$$p_i = 3040 \text{ psf} \quad \text{OK} \checkmark$$

TABLE [illegible] †

JOINT	OVERTURNING	SLIDING	[illegible]
J1	+MOMENT, STABLE	θ < f allow, STABLE	R WITHIN MIDDLE THIRD, STABLE
J2	+MOMENT, STABLE	θ < f allow, STABLE	R WITHIN MIDDLE THIRD, STABLE
J3	+MOMENT, STABLE	θ < f allow, STABLE	R WITHIN MIDDLE THIRD, STABLE
J4	+MOMENT, STABLE	θ < f allow, STABLE	R WITHIN MIDDLE THIRD, STABLE
J5	+MOMENT STABLE	θ < f allow, STABLE	R WITHIN MIDDLE THIRD, STABLE

* ORIGIN AT 1/3 L FROM DOWNSTREAM FACE ALONG JOINT

† NOTE : LOAD DUE TO BRIDGE ON SPILLWAY NOT INCLUDED IN ANALYSES, INSPECTION INDICATES RESULTANT OF THIS LOAD WILL BE LOCATED WITHIN MIDDLE THIRD OF STRUCTURE AND WILL ADD TO STABILITY.

B... Creek ... ML 00017 7-27-79

CASE II: DETERMINE STABILITY ... AT NORMAL POOL, NO TAILWATER, SILT AND ICE LOAD.

A. SILT LOAD SAME AS CASE I, A.

B. WEIGHT OF ... SAME AS CASE I, A, TABLE 1

C. DETERMINE ICE LOAD:

MAX TEMP RISE	:	70°F
TIME	:	12 hrs
RATE	:	5.8 °F/hr.
PRESSURE INCREASE	:	425 PSF/hr.
THICKNESS	:	2.5 Ft.

$$P_i = 2.5 \times 12 \times 425 = 12{,}750 \text{ Lb/ft}$$

NOTE: BRIDGE LOAD NOT INCLUDED (SEE NOTE PAGE E27)

D. TENSION, OVERTURN & SLIDING ANALYSIS:

JOINT 1 EL. ...7.0

LOAD	DESCRIPTION	FORCE (LB) HORIZ	FORCE (LB) VERT	LEVER* FT	MOMENT (Ft-Lb.)
WT	CONCRETE, TABLE 1		15,...	4.0	63,300
Up	(.5)(438)(17)		−3,723	5.7	−21,221
P_w	WATER .5(438)(7)	−1,533		2.3	−3,577
P_s	SILT .5(64)(2.5)	− 80		0.8	− 64
P_i	ICE	−1270		5.8	−7366
	TOTAL	−2883	12,252	(2.6)	31,672

$$\text{TAN } \theta = \frac{2883}{12{,}252} = .24 < f_{allow} = .70 \text{ OK}$$

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NATIONAL DAM INSPECTION PROGRAM. BROAD CREEK DAM (NDI-NUMBER-MD--ETC(U)
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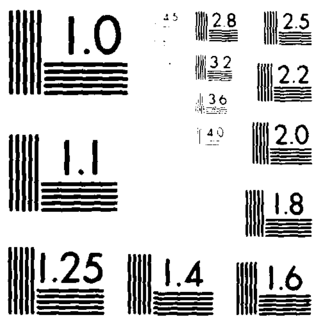

MICROCOPY RESOLUTION TEST CHART

O. (CONTINUED).:

JOINT 2, $L_2 = 20.6'$

LOAD	DESCRIPTION	FORCE (Lb.) HORIZ.	VERT.	LEVER* (Ft.)	MOMENT (Ft-Lb)
W_T	CONCRETE, TABLE 1		28,275	5.2	147,030
U_P	(.5)(688)(20.6)		-7,086	6.9	-48,893
P_W	WATER (.5)(688)(11)	-3784		3.7	-14,001
P_S	SILT (.5)(282)(6.5)	-916		2.2	-2,016
P_i	ICE	-1270		9.8	-12,446
	TOTAL	5970	21,189	(3.3)	69,674

$TAN\,\theta = \frac{5970}{21,189} = .28 < f_{allow} = .70$ OK

JOINT 3, $L_3 = 24'$

LOAD	DESCRIPTION	FORCE (Lb.) HORIZ.	VERT.	LEVER* (Ft.)	MOMENT (Ft-Lb)
W_T	CONCRETE, TABLE 1		42,675	6.3	268,852
U_P	(.5)(938)(24)		-11,256	8.0	-90,048
P_W	WATER (.5)(938)(15)	-7035		5.0	-35,175
P_S	SILT (.5)(384)(10.5)	-2016		3.5	-7,056
P_i	ICE	-1270		13.8	-17,526
	TOTAL	10,321	31,419	(3.8)	119,047

$TAN\,\theta = \frac{10,321}{31,419} = .33 < f_{allow} = .70$ OK

*ORIGIN AT 1/3 L FROM DOWNSTREAM FACE ALONG JOINT

JOINT 4 ; $L_4 = 26.5'$

LOAD	DESCRIPTION	FORCE (Lb.) HORIZ	VERT	LEVER* (Ft)	MOMENT (Ft-Lb)
W_T	CONCRETE, TABLE I		53,575	7.1	415,982
U_p	(.5)(1188)(26.5)		-15,741	8.8	-138,521
P_w	WATER .5(1188)(19	-11,286		6.3	-71,102
P_s	SILT .5(371)(14.5)	-2,690		4.8	-12,912
P_i	ICE	-1270		17.8	-22,606
	TOTAL	15,246	42,834	(4.0)	170,741

$$TAN\ \theta = \frac{15,246}{42,834} = .36 < f_{allow} = .70\ OK.$$

JOINT 5 ; $L_5 = 28.5'$

LOAD	DESCRIPTION	FORCE (Lb.) HORIZ.	VERT.	LEVER* (Ft)	MOMENT (Ft.-Lb.)
W_T	CONCRETE, TABLE I		79,950	7.4	591,680
U_p	(.5)(1500)(28.5)		-21,375	9.5	-203,062
P_w	WATER $(.5)(62.5)(24)^2$	-18,000		8.0	-144,000
P_s	SILT $(25.6)(.5)(19.5)^2$	-4,867		6.5	-31,636
P_i	ICE	-2,700		22.8	-61,650
	TOTAL	-25,567	58,575	(2.6)	151,332

$$TAN\ \theta = \frac{25,567}{58,575} = .44 < f_{allow} = .70\ OK$$

INCLINED STRESS AT BASE: $P_V = 58,575/28.5 + (58,575)(6)(2.6)/28.5^2 = 5041$ PSF

$$p_i = p_v \sec^2\phi = 5041 \sec^2\phi\ 26.6^\circ = 6305\ psf \quad OK\ \checkmark$$

*ORIGIN AT 1/3 L FROM DOWNSTREAM FACE ALONG JOINT

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APPENDIX F

GEOLOGY REPORT

STATE OF MARYLAND

DIRECTOR
KENNETH N. WEAVER

DEPUTY DIRECTOR
EMERY T. CLEAVES

TELEPHONE:
301 235-0771

MARYLAND GEOLOGICAL SURVEY
THE JOHNS HOPKINS UNIVERSITY
MERRYMAN HALL
BALTIMORE, MARYLAND 21218

July 30, 1979

Mr. Thomas J. Moynahan
Dam Security Division
Water Resources Administration
Tawes State Office Building
Annapolis, Maryland 21401

Dear Tom:

On our recent field investigation of the dam at Broad Creek Boy Scout Camp, Harford County, I made the following geological observations and conclusions:

The rock exposed at the dam foundations is a very fine grained, dark blue-green to black serpentinite, buff to light greenish-gray colored on weathered surfaces. The rock has been tectonically sheared and shows an indistinct, irregular foliation which is emphasized by the presence of the mineral chlorite. Enclosed within this sheared serpentinite are knots up to several feet across of massive, non-chloritic serpentinite. The serpentinite is resistant to weathering. However, when it does decompose most of the weathering products are soluble and are removed by groundwater. Very little residual material remains, so the soils which form on serpentinite are very thin.

Outcrops at the dam show that the rock is extensively cut by several sets of joints. The following joint sets were measured at the south abutment:

N69°W, 47°NE - Prominent, widely-spaced (0.2-1.0 meter) joints
N83°E, 60-74°SE - Many closely-spaced joints or foliation
N44-58°W, 45-61°SW - Widely-spaced irregular and curving joints
N-S, 35°W - Same
N25°E, 60°NW - Medium to widely-spaced joints
N40°E, 60°SE - Same

At the north abutment:

N70°W, 46°NE - Prominent, widely-spaced (0.2 to 1.0 meter) joints. Some of these joints have been healed and filled with an asbestiform mineral, probably picrolite

N-S, 51°E - Pervasive, closely-speaced joints or foliation

N15°W, 78°E

N10°W, 75°SW

N35°W, 60°NE

N80°E, 50°S

N50°W, 55°SW

All joint sets may have a range in the angle of dip of ± 10°.

In general, the rock exposed at the north abutment appears to be more talcose than that at the south abutment.

Although the rock is thoroughly broken by these joint sets the individual blocks of rock all interlock. There is no horizontal joint set parallel to the land surface and none of the joints intersect the axis of the dam structure in such a way as to present a potential bedrock failure surface in response to water pressure on the dam. However, blocks of bedrock may be plucked or lifted out of place by hydraulic action and may possibly undermine the downstream toe of the dam structure if the dam is overtopped by large amounts of water for a prolonged period.

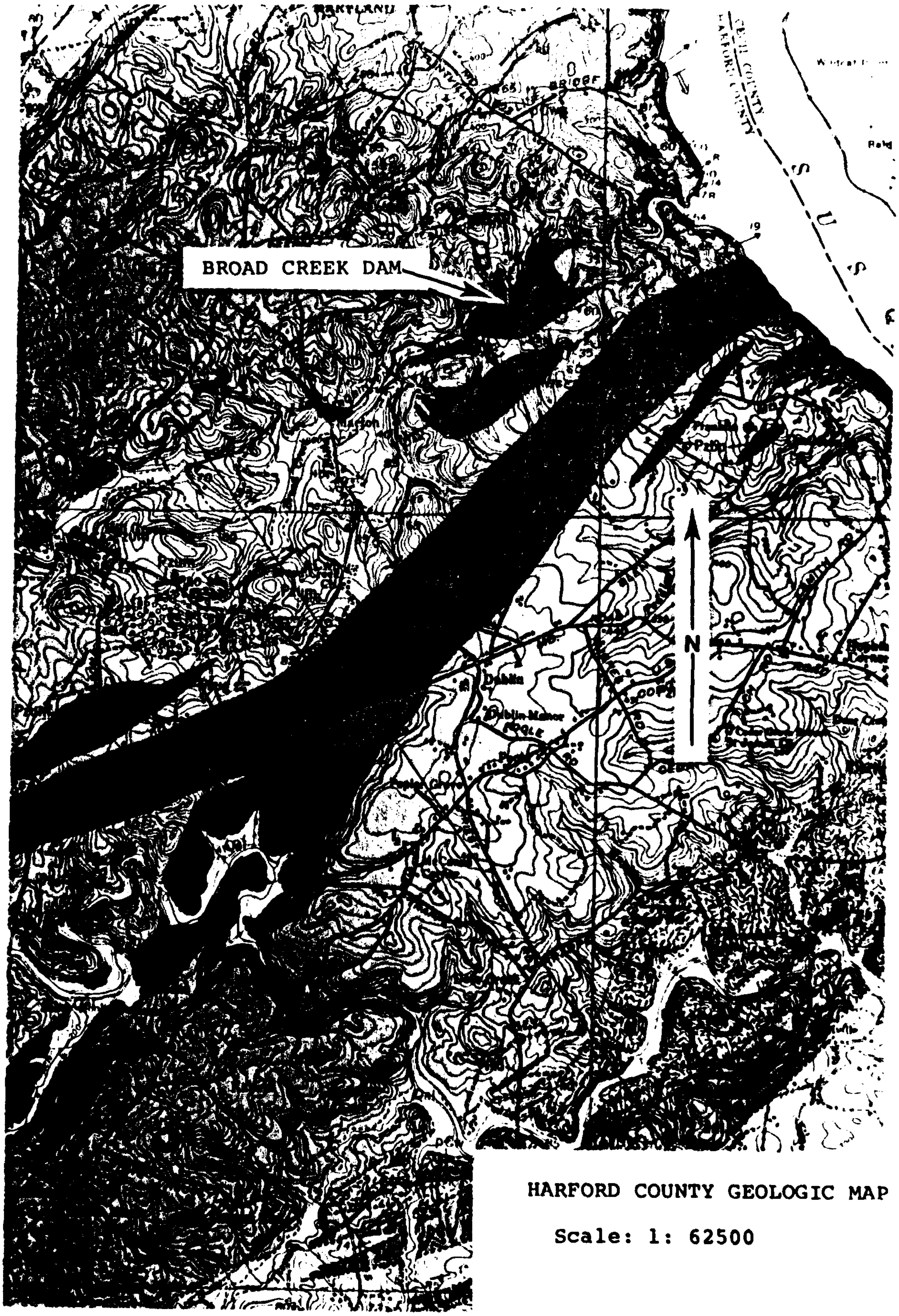
Thank you for inviting me along on your inspection tour. I hope that the above information is satisfactory and will help you in your report on the safety of the dam.

Sincerely yours,

John Edwards

Jonathan Edwards, Jr.
Geologist

JE/kc



HARFORD COUNTY GEOLOGIC MAP

Scale: 1: 62500

HARFORD COUNTY GEOLOGIC MAP

LEGEND

Glenarm Series

Wissahickon Formation

pCwu, upper pelitic schist, *chiefly albite-chlorite-muscovite-quartz schist with a few thin beds of fine-grained, laminated metagraywacke. Albite porphyroblasts as large as 5 mm are common and especially prominent in northwest part of county. Biotite and garnet, commonly chloritized, occur locally.* gs *greenstone*

pCwg, metagraywacke, *rhythmically interbedded metagraywacke and fine-grained pelitic schist. Composed chiefly of chlorite, muscovite, sodic plagioclase, and quartz; locally contains biotite, garnet, and chloritoid. Graded bedding locally preserved in metagraywacke. Rocks containing more than 25 percent metagraywacke mapped as* pCwg; *those with less mapped as* pCwu

pCwc, metaconglomerate, *silver-gray, schistose, micaceous quartz-pebble metaconglomerate and quartzite; contains small amounts of chlorite, chloritoid and kyanite. Closely resembles the Cardiff Metaconglomerate, but no structural connection between the two could be demonstrated*

pCwb, boulder gneiss, *thick-bedded to massive biotite-muscovite-plagioclase-quartz metagraywacke, locally with chlorite or garnet; contains lenses of metamorphosed, conglomeratic sandstone. The conglomeratic lenses contain angular to rounded fragments of vein quartz, metagraywacke, biotite schist, amphibolite, and quartz diorite in a weakly foliated, feldspathic, arenaceous matrix that in places resembles granite or granitic gneiss.* pCwb *can be distinguished from* pCwg *only by the presence of conglomeratic lenses, the largest of which are shown by a pattern of circles*

pCwl, lower pelitic schist, *chiefly biotite-muscovite-plagioclase-quartz schist with accessory garnet, staurolite, and kyanite in appropriate metamorphic zones; sillimanite occurs locally, but not in mappable zones. Thin beds of sugary quartzite and metagraywacke make up less than 10 percent of the section. Grades upward and laterally into* pCwb, pCwu, *and* pCwg. *Zones of retrograde chlorite-bearing schist fairly common but of regional extent only where shown by pattern.* am *amphibolite*

Ultramafic rocks

Chiefly serpentinite and massive to schistose soapstone; talc-carbonate rock and altered gabbro are common in some bodies. Actinolite schist, talc-actinolite schist, chlorite-actinolite schist, and blackwall chlorite rock are developed near wallrock contacts, in narrow, constricted areas, and in some shear zones

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